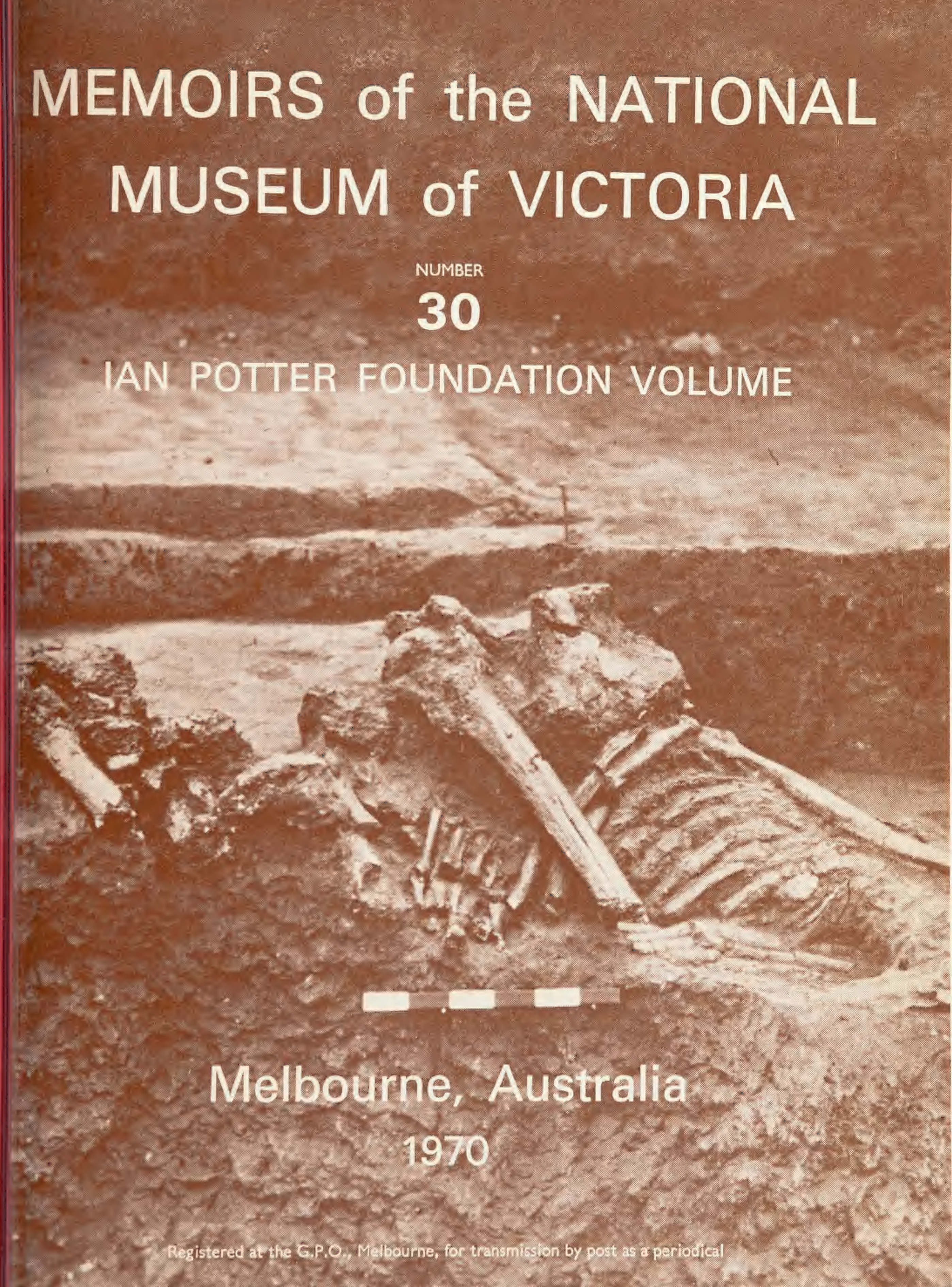


MEMOIRS of the NATIONAL MUSEUM of VICTORIA

NUMBER
30

IAN POTTER FOUNDATION VOLUME

Melbourne, Australia
1970

Registered at the G.P.O., Melbourne, for transmission by post as a periodical

MEMOIRS

of the

NATIONAL MUSEUM OF VICTORIA

MELBOURNE AUSTRALIA

No. 30

PUBLISHED BY ORDER OF THE TRUSTEES

1970

NATIONAL MUSEUM OF VICTORIA

Staff

Director: John McNally, ED MSc
Deputy Director: Edmund D. Gill, BA BD FGS FRGS
Administration: A. G. Parsons (in charge)
D. E. Quinn
E. J. Peat
G. H. Russell
Patricia Rogers
Nancie Wortley
Gwenda Bloom

Scientific Staff

Geology and Palaeontology:
Curator of Fossils: T. A. Darragh, MSc DipEd
Curator of Minerals: A. W. Beasley, MSc PhD DIC FGS
Assistant Curator of Fossils: K. N. Bell, BSc DipEd
Assistant: J. K. Jamieson

Vertebrate Zoology:
Curator of Vertebrates: Joan M. Dixon, BSc (Hons)
Curator of Birds: A. R. McEvey, BA
Assistants: A. J. Coventry
M. Jane Washington

Invertebrate Zoology:
Curator of Insects: A. Neboiss, MSc FRES
Curator of Invertebrates: B. J. Smith, BSc PhD
Assistants: Elizabeth M. Matheson
Leonie L. Convey

Anthropology:
Curator of Anthropology: A. L. West, BA Dip Soc Stud
Assistant: J. A. S. Holman

Library:
Librarian: Joyce M. Shaw, BA
Assistant: Margret A. Stam

Display Staff:

G. J. Browning
D. T. Morgan

Preparatorial Staff:

P. C. R. Boswell (Senior Preparator)
L. J. Chapman
M. G. Traynor
A. Sten

Education Officers:

N. W. Morley, BSc BEd
L. E. Leeson
R. N. Miller
Marie-Therese Murphy

Honorary Associates
with year of appointment

Geology:

A. A. Baker, 1951
G. Baker, DSc, 1956
A. C. Collins, FRAIA ARIBA AMTPI MACE, 1953
J. G. G. Douglas, MSc PhD, 1966
J. A. Talent, MSc PhD, 1966
D. J. Taylor, MSc, 1966
J. W. Warren, MA PhD, 1968

Vertebrate Zoology:

C. N. Austin, 1955
C. W. Brazenor, 1962
A. G. Brown, MRCS (Eng) LRCP (London), 1968
R. P. Cooper, FNIA, 1952
N. J. Favaloro, 1945
P. A. Rawlinson, BSc, 1968
C. Tanner, 1953
R. M. Warneke, MSc BAgrSc, 1966
H. N. B. Wettenhall, MD BS MRCP FRACP, 1963

Invertebrate Zoology:

J. Hope Black, MSc (née Macpherson), 1966
R. F. Burn, 1962
A. N. Burns, MSc FRES, 1966
J. E. H. Crofts, 1960
D. F. Crosby, FRES, 1968
R. A. Dunn, AAA AAIS, 1948
Florence V. Murray, MSc, 1969
R. L. Jensz, BSc DipEd, 1968
E. T. Smith, 1960

Anthropology:

D. A. Casey, MC FSA, 1933
J. H. McNamara, MB BS, 1969

CONTENTS

THE GREEN GULLY BURIAL

Report on archaeologic excavations at Green Gully, near Keilor, Victoria, Australia.

COVER ILLUSTRATION

The excavation showing human remains at Green Gully.

This Memoir is named the IAN POTTER FOUNDATION VOLUME in recognition of the generous support of that Foundation in the excavations and in the production of this report.

THE GREEN GULLY BURIAL

An Introduction By D. J. MULVANEY
Australian National University

The Green Gully human remains were a chance discovery made during August, 1965. Bone collagen radiocarbon analysis later determined their age as 6460 ± 190 B.P., but evidence for possible human activities at the site extends back some 17,000 years.

The fact that the bones lay within two miles of the soil pit which, in 1940, produced the controversial Keilor cranium, that they were apparently embedded in the same terrace sediments, and that post-cranial bones survived, excited scientific interest. One of those rare opportunities in fossil human research was presented, with an *in situ* fossil which could be recovered under controlled circumstances, in conjunction with related archaeological and geomorphological studies. The Keilor Project Committee was established under the chairmanship of Mr J. McNally, the Director, National Museum of Victoria, to co-ordinate field and laboratory research.

It is an indication of the rapid progress in Australian prehistoric research, that human remains 6,000 years old are less significant in 1970 than at the time of their discovery. The antiquity of the human occupation of this continent has been pushed back far into the late Pleistocene, and research on other known human fossils, together with the discovery of further remains, is permitting new time perspectives. Even so, the Green Gully project resulted in the accumulation of data relevant to local prehistoric racial, cultural and environmental patterns, at a level of detail rarely achieved in Australia. It is only by such detailed concentration on selected sites or problems that a realistic appraisal of more general issues will become practicable—the climate, landscape and society of Aboriginal Australia.

This *Memoir* presents several facets of the Green Gully project. Work is continuing on the centrepiece, the human remains, under the direction of Professor N. W. G. Macintosh, who was overseas at the time of the discovery and excavations. The bones present many problems of identification, reconstruction and interpretation. These investigations will occupy some time, and it was decided to publish the present papers without further delay. As an interim measure, and with the concurrence of Professor Macintosh, an abbreviated account of some salient preliminary observations already published by Macintosh has been prepared by the writer (pp. 93-100).

To judge from the preliminary assessment of the human remains, the Green Gully burial verged on the bizarre. Delayed interment practices are indicated, but although no bones were duplicated, bones belonging to more than one individual were buried; evidently both sexes were represented. The anomalous circumstances of this composite burial make a full investigation of relevant Aboriginal ethnographic practices a desirable addendum to the published final report on the human remains.

Individual authors have acknowledged their debt to many collaborators and their names are not repeated here; others assisted who are not named, but the thanks of the Keilor Project Committee and of the chief participants are extended to them. It is necessary to single out the following persons, however, for specific services. Mr Donald Mahon, proprietor of the soil pit showed a sense of responsibility by reporting his discovery, as did the owner of the property, Mr H. Dodds, when both he and Mr Mahon assented to the work taking place. Professor E. S.

Hills, Chairman of Trustees of the Museum, took the initiative in arranging financial support for the project, while the Museum Director, Mr J. McNally, assisted in many ways. Mr McNally served also as Chairman of the Keilor Project Committee, and Mr E. D. Gill was its secretary. It merits record that over many years Mr Gill's visits to soil pits in the region alerted Mr Mahon to the potential significance of his discovery.

Costs of the project were supported partly by the Museum and by the Australian National University, Canberra. A contribution was made to the initial work by the Australia and New Zealand Bank Ltd. The major financial sponsor was the Sir Ian Potter Foundation. To all these sponsors, the Keilor Project Committee acknowledges its gratitude.

The writer was appointed by the Committee to co-ordinate the papers. He thanks the authors for their co-operation. This *Memoir* is published under the terms of the Ian Potter Foundation grant.

EXCAVATION OF THE GREEN GULLY BURIAL

By D. A. Casey
Honorary Associate in Anthropology
and T. A. Darragh
Curator of Fossils

Abstract

The discovery and excavation of human remains found in an ancient river terrace of the Maribyrnong R. near Keilor, Victoria, are described. The remains were in a shallow grave sealed by three feet of undisturbed soil. Radiocarbon analysis indicates that the bones are about 6460 years old.

Introduction

In August 1965 fossil human bones were found in a pit (from which garden soil is excavated for sale) near Keilor, about 10 m NW. of Melbourne. The pit is on a farm property belonging to Mr H. Dodds on the right bank of the Maribyrnong R. about one mile S. of the township of Keilor. It is immediately downstream from the point where Taylor Ck, which flows down Green Gully, joins the river (Lat. 37° 44′S., long. 144° 50′E. Military Map 1 in. = 1 mile, Sunbury Sheet 871464).

The site had been visited previously on several occasions by Mr E. D. Gill, Assistant Director of the National Museum of Victoria, and he had asked the proprietor of the pit, Mr Donald Mahon, to let him know of any fossil bones or stone implements found during excavation. When the bones were first noticed, Mr Mahon, realizing that they were probably of interest and importance, left them undisturbed and notified the Museum of their discovery. The site was immediately visited by Mr T. A. Darragh, Curator of Fossils at the Museum.

Occurrence

The soil pit was about nine feet deep where the bones were found, and they were visible in position in the more or less vertical face of the pit, at a depth of about 3 ft 6 in. from the surface. The present surface of the ground is here the original natural surface, and it has not been disturbed by the removal of soil. The bones appeared to be lying on a slightly concave surface. A cranium could be seen on the right-hand side as viewed in the face of the pit, and other bones extended to the left. The whole covered about three feet laterally. Apart from the cranium, the various bones visible could not be clearly identified. Some had been disturbed and broken away when they were uncovered by the front-end loader used for excavating the soil. Some of the dislodged bones and fragments were recovered from the loose earth at the foot of the face, and amongst these there was a fragment of a frontal bone with part of the margin of one orbit and part of the supra-orbital ridge, and this was clearly human. Other fragments, and two teeth, were recovered later, but no doubt some were lost in soil removed from the pit. It was assumed that the bones were the remains of a human skeleton.

There was evidence of some disturbance of the soil immediately above the bones, but apart from this there was no sign of a grave. An examination of the soil face showed that the bones were covered by about three feet of apparently undisturbed soil and alluvial sediment. This deposit is part of a river terrace, the

surface of which is about 36 ft above the level of the river. This terrace is the third highest of a series of four terraces in this locality. It is the same terrace (the Keilor Terrace) as that in which a human cranium was found in 1940 in a sand pit four miles further up the valley of the Maribyrnong R. and two miles away in a straight line. About three feet below the bones there was visible in the face of the pit a large area of oxidized earth with a considerable amount of charcoal and ash. This extended for several feet laterally, and at one place for at least two feet vertically. In the vicinity of the bones there was some burnt earth distributed through the soil in the form of pink granules. However, the relationship of the main mass of burnt material to the bones, or if there was in fact any relationship between them at all, was not clear. The discovery was obviously of considerable importance, and it was clear that the bones should be properly excavated without delay. They were exposed to the weather and were liable to be damaged by rain or storm, and they were also liable to be disturbed or damaged through the curiosity of casual visitors.

With the ready permission of the owner of the land, and of the proprietor of the soil pit, the Director of the National Museum of Victoria, Mr John McNally, immediately took steps to arrange for the excavation of the bones and for the investigation of their stratigraphy and environment. T. A. Darragh was placed in charge of the excavation, assisted and advised by D. A. Casey, Honorary Associate in Anthropology at the Museum. J. M. Bowler, of the Department of Geology, University of Melbourne, and later of the Department of Geography, Australian National University, undertook the investigation of the geomorphology at the site. Later, D. J. Mulvaney, of the Department of Anthropology, Australian National University, joined in the conduct of the excavation. Until a permanent camp could be established and the excavation started, it was arranged that a constant watch should be maintained in order to prevent any unauthorized interference with the bones, and for several days the Victoria Police co-operated in maintaining this watch.

At the instigation of Professor E. S. Hills, archaeologists and other scientists likely to be interested in the discovery were invited to view the bones *in situ* before excavation was started, and Dr D. E. Thomas of the Victorian Department of Mines, and J. N. Jennings and J. Golson of the Australian National University, visited the site. Mr Golson arranged for R. Lampert, Field Officer of the Department of Anthropology, A.N.U. to assist in the excavation; he was present during most of the excavation, and gave much expert assistance. Dr Thomas arranged for J. Knight and R. Williams of the Geological Survey of Victoria to survey the site. Mr J. A. Blackburn, Licenced Surveyor, undertook the surveying necessary to fix the position of the burial precisely (Fig. 1), and to determine the exact relative positions of the several separate excavations that were carried out at the soil pit. Mr Blackburn also determined the height of the excavation datum point in relation to the Melbourne and Metropolitan Board of Works datum. All heights mentioned in this report are referred to as Reduced Levels (R.L.) above the M.M.B.W. datum (Low water at Hobson Bay).

During the excavation, members of the staff of the National Museum of Victoria gave much assistance with the work and also helped in maintaining a night watch. Miss Anne Bermingham of the Institute of Applied Science assisted in collecting charcoal samples for the purpose of C14 dating, and selected samples were dated by her in the laboratory at the Institute.

Excavation of the Bones

The excavation was carried out by digging down from the surface of the terrace. There was no apparent stratification of the soil, and it was removed in horizontal spits, each of a few inches in depth. The excavation showed that the

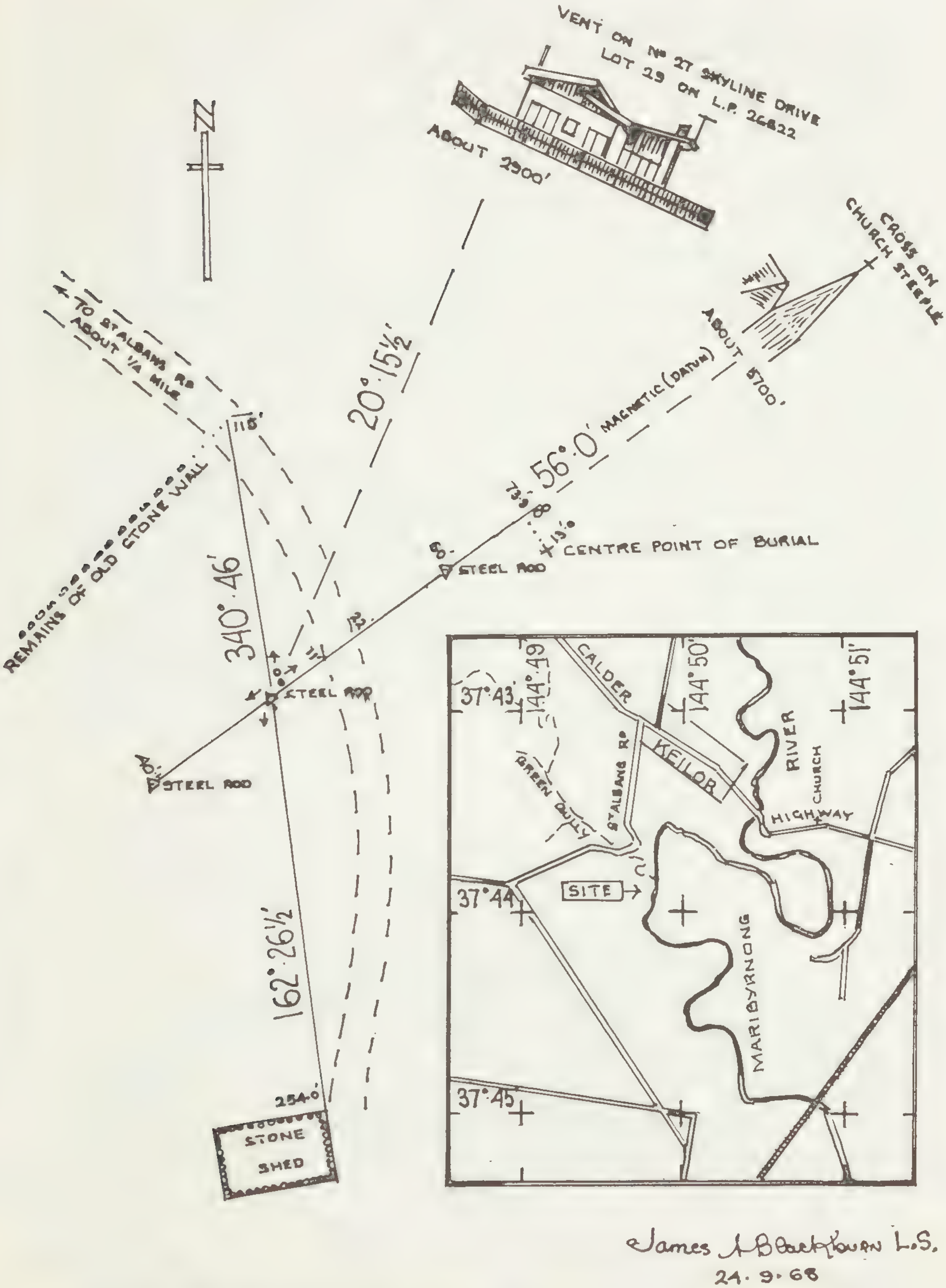


Fig. 1—Survey data fixing position of burial. Additional information is filed in the Museum archives.

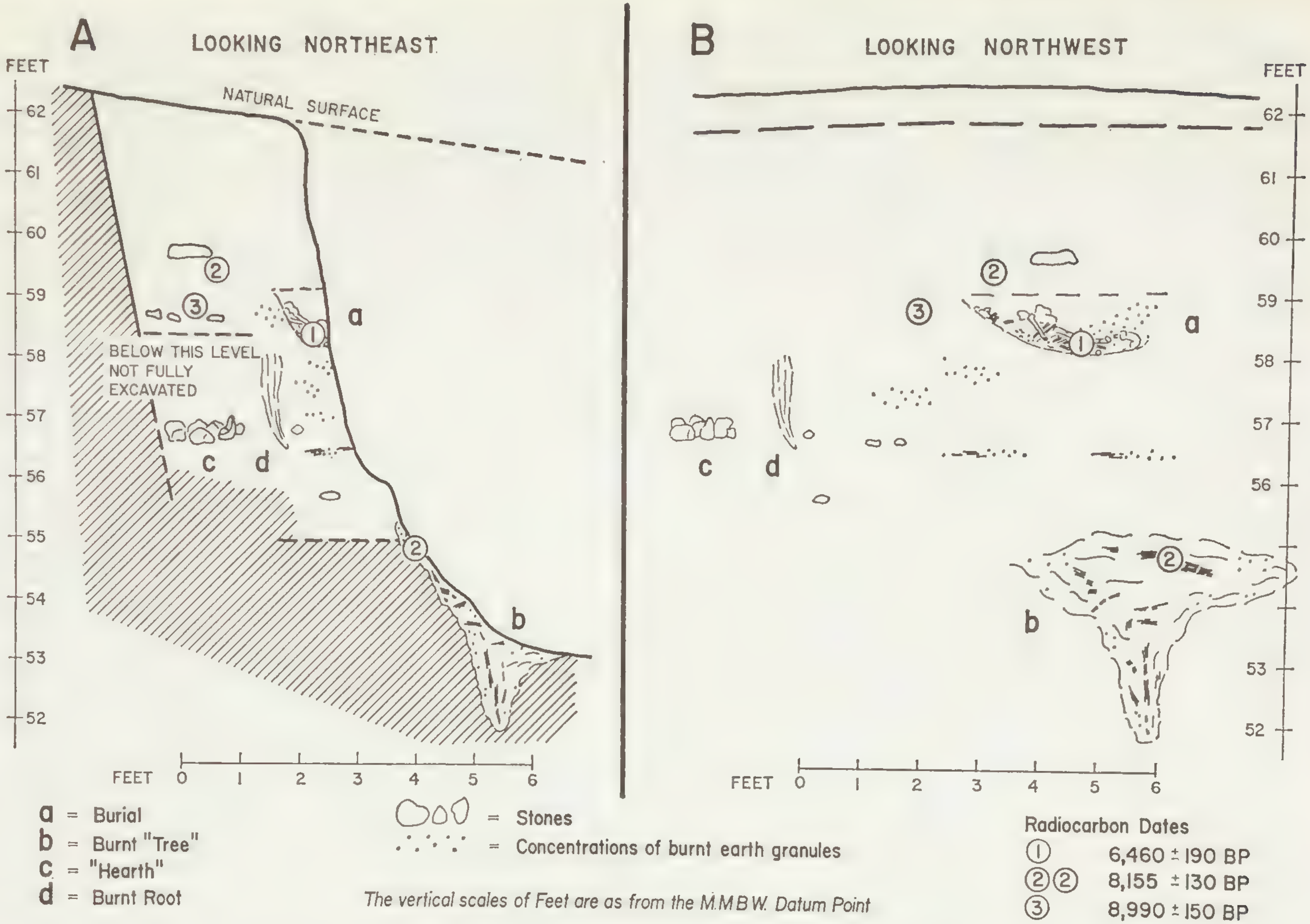


FIG. 3 A, B—Vertical sections of burial site. Objects in these drawings are shown as if projected on vertical planes at right angles to each other. The relative spatial positions of the objects may thus be seen by comparing the two drawings.

bones were indeed human, and confirmed the fact that there was at least three feet of quite undisturbed soil and sediment above them, and that there was no deep grave. The bones were clearly not an insertion into the terrace and were truly fossil. However, as the soil was removed from immediately above and around the bones, it became clear that they were resting in a shallow grave, and the outline of this could be seen in plan, marked by a zone of darker soil. This was most clearly seen around the NE. end of the grave. Much of the filling of the grave at this end had a considerable mixture of burnt earth of a pink colour, and was consequently lighter in tone than the adjacent earth. The limits of the grave were not so well marked at the other end, but its existence here was clearly indicated by the fact that the soil around the bones was very much darker than the adjacent terrace material. The zone of dark soil around the bones was quite clear, although its limits were nowhere sharply or precisely marked (Fig. 2). These facts would seem to indicate that it was a grave dug into comparatively loose soil and filled in shortly afterwards, and that it was not merely a natural hollow. If a natural hollow had been utilized as a grave, it might be expected that the junction between the undisturbed sides of the hollow and the grave filling would have been distinct and precisely noticeable.

The surviving part of the grave extended back about nine or ten inches from the face of the cut as left by the front-end loader. Vertically, the grave extended upwards for about twelve inches from the lowest point of the surface upon which the bones lay (Fig. 3). On the face of the cut, above the NE. end of the burial, there was visible a tip of burnt earth oxidized to a pinkish orange colour, which had not been burnt *in situ*. It sloped down in such a way as to suggest that it had been tipped down, or had fallen down over the bones. Excavation revealed that this inference was correct. The burnt material sloped down from a point above and beyond the cranium, and spread out so as to cover the whole of the cranium and thorax. It passed over the cranium but was not around the sides of it. It must be supposed that the bones were deliberately and intentionally buried.

The remains were lying on their left side, with the knees drawn up. The burial

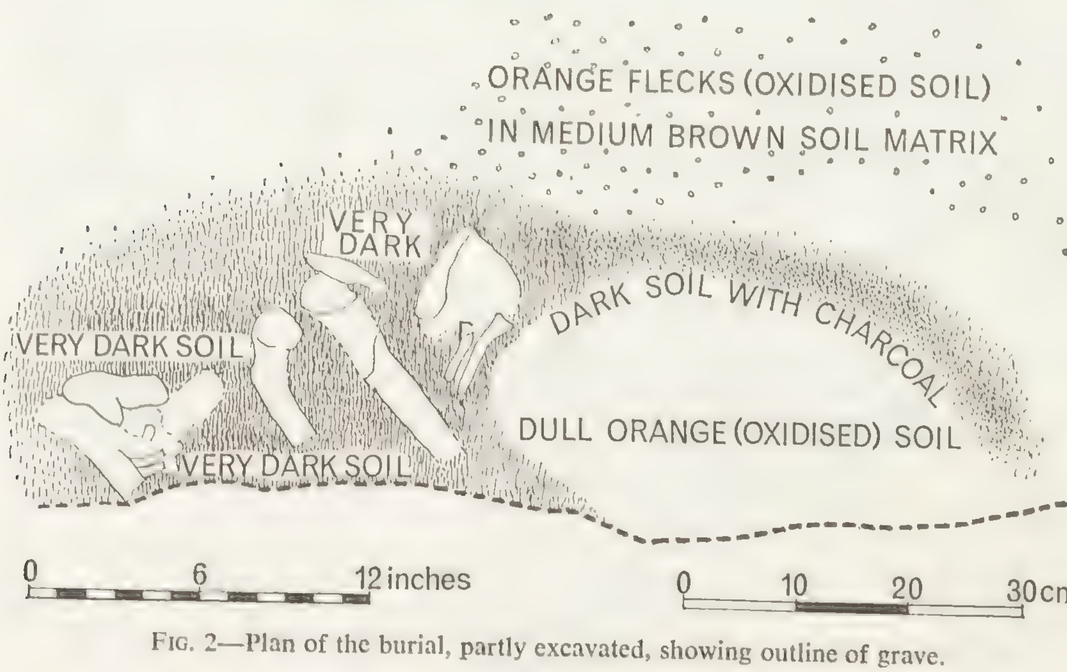


FIG. 2—Plan of the burial, partly excavated, showing outline of grave.

was oriented in about a NE.-SW. direction, with the skull towards the NE. The skull end of the burial was lying several inches lower than the feet end. The facial bones had been broken away and damaged when uncovered by the front-end loader, as had also the knee joints and the adjacent parts of the long bones of the legs. (Pl. 1 and Fig. 4). The bones of the feet, legs, and the pelvic region were darker in colour and were in a more fragile condition than those of the thorax, arms, and cranium, presumably because of a difference in the filling of the two parts of the grave. None of the bones could have been lifted without some danger of being damaged and they were all either fragile or considerably fractured.

As the earth was gradually removed from around and about the bones, each bone as it was revealed was painted with a strengthening solution (a dilute solution of Bedacryl in acetone). No attempt was made to remove the bones separately, but it was decided to lift them as they lay, in three blocks: the cranium, the thorax, arms and pelvic region, and the feet, so that they could be carefully and deliberately examined in the laboratory. When the bones had been strengthened as far as was practicable with the Bedacryl solution, each block was covered with several layers of paper, pasted on in small pieces, to protect the bones from the plaster to be used for reinforcement. Each block was then reinforced with plaster of Paris bandages, and after undercutting was lifted and removed.

It is of course not possible to know how far the grave extended on the side that was removed by the front-end loader, and the possibility that the burial might have been inserted from this side, down a sloping grave shaft, has to be considered, but is remote. The grave as revealed by the excavation was shallow, and was open at the top, and the inner side and lip were clearly, if not precisely, defined. There was no sign of undercutting. As well as this, the filling at the skull end, as previously described, had evidently been tipped down from above. These facts would preclude the possibility of the burial having been made through a lateral sloping shaft.

In recent times the natural surface of the ground sloped down, from about the vicinity of the burial site, towards the river for a short distance. This slope apparently represented the margin of the terrace. This part of the terrace no longer exists, having been removed in the process of digging out the soil from the pit. Nevertheless the position and extent of the recent sloping surface and its angle of slope are known fairly accurately. From a plan and a series of levels which were made for the owner of the land prior to the development of the site as a soil pit, it has been possible to deduce the approximate contours of the recent surface. The direction of its slope was towards the E., i.e. towards the river, and its maximum gradient was only about eight degrees. Moreover, according to Mr Mahon, there was no large hole or irregularity in the surface hereabouts, and it was a gentle unbroken slope. This is confirmed also by air photos of the site taken before the soil pit was started. The maximum probable slope of the surface is marked on the drawing of the vertical section of the site by a dotted line (Fig. 3A). It will be seen that it is extremely unlikely that a grave shaft could have extended down from anywhere near this surface. The distance is too great.

A grave shaft could conceivably have reached down to the position of the burial at some earlier time, when the surface of the ground here was considerably lower, perhaps when it was some two feet lower. However, if it were necessary to doubt the validity of the evidence in regard to the grave provided by the excavation and to consider this further possibility, the burial would still, in this hypothetical case, have to be considered as ancient and not recent, as it would have been sealed by the upper two feet of the terrace sediments.

The Human Remains

Professor N. W. G. Macintosh has indicated that the Green Gully human remains may perhaps consist of parts of two individuals, but there is not yet sufficient

evidence to show that this was certainly so and it is still to be regarded as a possibility only (See N.W.G.M. this *Memoir*, and *Aust. J. Sci.* 30: 86-98). However, if further examination and study of the bones should confirm this supposition, the burial would indeed be a very remarkable one, and it may be as well to consider here what the significance of such a burial would be and some of the deductions that would have to be drawn from it.

The burial may well have been a delayed one, as Professor Macintosh has suggested, but as may be seen from Plate 1 and Figure 4 the remains were far from being completely disarticulated. Although they were somewhat collapsed, as all burials become in the course of time, the bones were, as far as could be seen, in approximately their correct natural order and in approximately their correct relative positions. It is thus apparent that the delay between death and burial could not have been very long. It would be quite possible, of course, for parts of two desiccated bodies to have become mixed by mistake when the time came to take them up for burial. But in this case it does not seem very likely that an error of this sort was made. It must be supposed that a people whose practice it was to delay the burial of their dead, and to eventually bury their remains in prepared graves, must have cared considerably about their dead and about the proper disposal of their remains. This being so, it would seem most unlikely that errors would be made in the identification of the remains of individuals, and this would be particularly so when a burial took place not long after death. Such errors may undoubtedly have occurred sometimes, but it is highly improbable that they would be anything but rare (or even very rare) occurrences. It is hardly credible therefore that the first burial of great age to be discovered and excavated in Australia should be the result of such a rare occurrence. If it was not the result of an error, such a dual burial might perhaps have occurred through mere carelessness or heedlessness in the disposal of the remains, but this does not seem to be a likely explanation in this case. If the burial was indeed a dual one, it is clear that considerable care was taken in positioning the several parts in the grave so that they simulated a normal burial of a single individual. Also, although many of the bones had disintegrated, none of the surviving bones had been duplicated and there were no indications of any bones having been missing at the time of burial. It is evident that there could not have been any lack of care or any heedlessness in the carrying out of the burial.

If it is eventually shown that the burial was in fact a dual one, it will have to be assumed that it was either the result of an error or mistake, or perhaps of carelessness, or that it was the result of a deliberate and purposeful act. There is no other possible way in which it could have occurred, and extraordinary though it may seem, the latter explanation would have to be accepted as the most probable one.

Burnt Tree, and other Signs of Burning

After the removal of the bones, the excavation was continued downwards in order to examine the large mass of burnt material, and to determine whether this had any connection with the burial. The burnt earth, ash, and charcoal proved to extend down at one place to R.L. 51 ft 9 in., i.e., it extended vertically for 3 ft 6 in. overall. The lower two feet included burnt-out roots in position of growth. They were confined within a fairly narrow vertically tapering space, and in this there were many large pieces of charcoal, all positioned with the grain of the wood more or less vertical (Fig. 3). The main mass of burnt material was immediately above this, and had a depth of about 1 ft 6 in. There were in this many very large pieces of charcoal arranged irregularly. The whole mass was presumably the remains of the roots, and perhaps the fallen branches of a burnt tree. It was evident that the

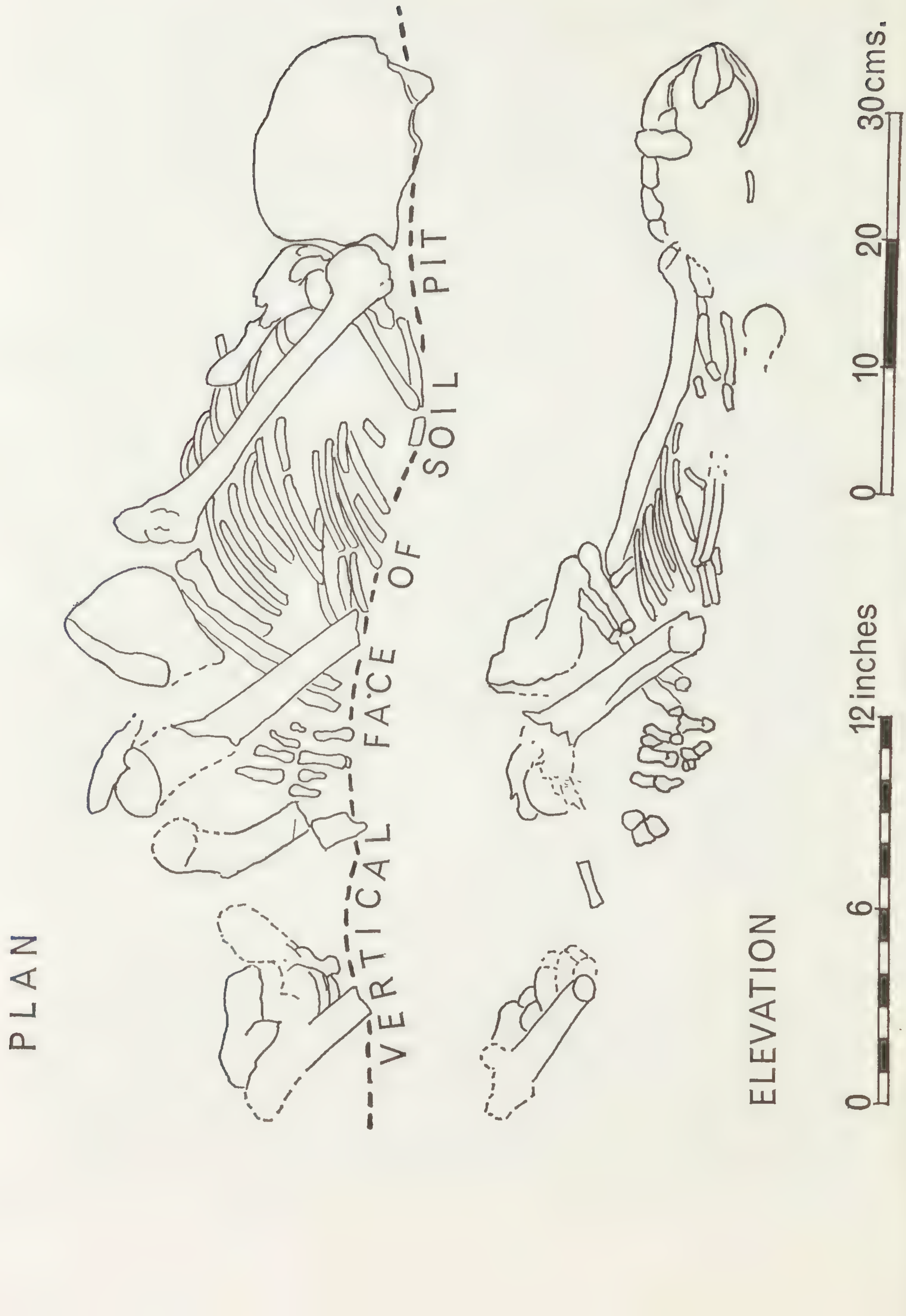


FIG. 4—Plan and elevation of burial.

whole had been burnt *in situ* as the soil immediately adjacent to the burnt material was burnt, and oxidized to a pink or red colour. Unfortunately much of the upper part of the burnt material had been removed in the process of taking soil from the pit, and what remained was only a few inches thick. It was not possible to determine just where the surface of the ground had been upon which the tree had grown, but it could not have been higher than the upper limit of the burnt material, and it could hardly have been much lower than this.

The top of the grave was at R.L. 59 ft 1 in., and the top of the burnt material was at R.L. 55 ft 3 in.; they were thus 3 ft 10 in. apart vertically. There was no evident connection between them, and the proximity of the two in plan was apparently quite fortuitous. However, from about the level of the top of the grave to about R.L. 56 ft 6 in. there were in places granules of burnt earth distributed through the soil, and subsequent excavation (See D.J.M.'s report) showed that there was a fairly large burnt root in position of growth, some three feet beyond the foot of the grave to the SW., and between R.L. 56 ft 6 in. and 58 ft (Fig. 3). As well as these evidences of burning there was (as previously mentioned) burnt earth in the filling of the grave, and this presumably came from some burnt area adjacent to the grave and upon the surface into which the grave was dug. It cannot be supposed that all this burning, at various levels over a vertical range of seven feet, took place over such a great period of time as might be suggested by this considerable range of depths. The most likely explanation would be that the burning was all on or about the sloping margin of the terrace, and that it was the result of a bushfire or perhaps several fires which all took place at about the same time. Evidence of burning was noted in many places elsewhere in the soil pit, and all of this may well have been on or about the same stratigraphical horizon. It was not possible to confirm this because of the varied extent and range of the soil digging operations in the pit.

From the alignment of the terrace margin (as evident in adjacent parts of the soil pit) it is clear that it must have passed either through or just E. of the burial position, and the grave must have been either on or close to this slope. The excavation at the burial site did not however reveal any sign of such a sloping surface, or any sloping bedding lines in the soil. Presumably the grave was at or near the top of the slope and the whole of the actual margin of the terrace was removed in the process of digging the soil from the pit. There was little chance of this sloping surface being revealed by the excavation, as not only had the soil been entirely removed from the SE. side of the burial, and part of the grave itself, but beyond both ends of the grave only a few feet of soil remained undisturbed by the front-end loader. This problem is discussed further in Bowler's contribution to this *Memoir*.

Stratification of the Burial Site

The surface soil to a depth of about 1 ft 6 in. or 2 ft from the surface was of a dark colour, but at this depth the colour gradually changed to a lighter tone of grey. At a depth of about 6 or 7 ft, i.e. at about R.L. 57 ft to 55 ft, the soil again changed gradually to a lighter tone and became somewhat yellowish or brownish in colour. These changes are however inherent in the sediment of the terrace and bear no relationship to human occupation. Apart from these changes of colour, the material appeared to be of an even consistency from the surface right down to the full extent of the excavation.

In the course of the excavation a number of stone artifacts was found, as well as some bones, bone fragments, and charcoal, and the disposition of these revealed a definite stratification. The artifacts, incorporated with subsequent finds, are described and analysed by D. J. Mulvaney elsewhere in this *Memoir*. The charcoal

was collected, and some samples have been used for radiocarbon analyses. It is only necessary here to record the stratification.

From the surface down to a depth of about 4-8 in. according to the slope of the surface, i.e. to about R.L. 61 ft 6 in., the artifacts recovered were small flakes and cores and a number of small blades and fragments of blades of the type used only for the making of microlithic implements, although no actual microliths were found. For a further three inches below this, at one place, there was a number of quartz fragments, somewhat flake-like in form, but these may have been part of the microlithic assemblage. From about R.L. 61 ft 3 in. to 60 ft there was a sterile zone with no artifacts or any other sign of occupation. Below this to at least R.L. 55 ft, which was about the greatest depth reached in this excavation, there was a rather crude flake industry. The artifacts were distributed through the soil indiscriminately, except that at R.L. 56 ft 5 in. there was a slight occupation horizon containing some flakes, charcoal, and granules of burnt earth.

The artifacts included flakes of various sorts and sizes, none of them very large, two definite trimmed flake implements, and several flakes with some secondary trimming. The material used was mostly quartzite of a variety of colours, textures, and grain sizes. Together with the flakes and flake implements there was a number of broken pieces of small basalt pebbles. These were 2-3 in. in length and about 1·5 in. thick. Each had some cortex surface and one or more fracture surfaces. They were in sufficient numbers, and were sufficiently even in size and shape to constitute a distinct group. There is no obvious natural process which could result in such fragments, and they are considered to be artifacts, or at least the result of some human activity, although no function or purpose can be assigned to them. At one place five such pieces, rather larger than most of the others, were found lying together. These fit together to make about three quarters of a complete pebble which would have measured about 11 in. × 8 in. × 3 in. The only explanation of this would seem to be that the pebble was broken *in situ*, presumably on purpose. The missing piece may have been removed, or lain laterally and was removed by the front-end loader.

From below the sterile zone, i.e. R.L. 60 ft, occasional small bones and fragments of bones, and also some charcoal, occurred throughout the deposit. The charcoal was distributed through the soil in small fragments, or it occurred in small concentrations. Nowhere did it seem to have been burnt *in situ* (except in the burnt tree), and there were no definite fireplaces or hearths.

The microlithic flakes and cores, and the association of the flake industry, the basalt fragments, the small bones, and the charcoal, indicates the existence of human occupation at this site for a considerable length of time. However, from the level of the grave downwards, only about half a cubic yard of earth was excavated during the September excavation, and artifacts found below the level of the grave may not be truly representative of these levels.

Calcium Carbonate Encrustation

Below the level of the burial, i.e. from about R.L. 58 ft 3 in., virtually all the stone flakes and fragments, and the small bones and fragments of bone, were covered with a calcium carbonate deposit, or at least were partially covered. This incrustation did not occur at all at levels higher than this. Such incrustation results merely from the presence of calcium carbonate in the soil, and bears no relationship to human occupation. It should be noted that the flake industry persisted well above the upper limit of the calcium carbonate. The fact that the level of the bottom of the grave coincided with the upper limit of the calcium carbonate in the soil would appear to have no particular significance and to be quite fortuitous. This matter is discussed further by J. M. Bowler in his contribution.

Radiocarbon Age Estimations

The age of the burial has been determined from a sample of bone collagen:
N.Z., 6460 ± 190 B.P. (Fig. 3, 1).

Estimations of age have also been made from samples of charcoal found in the vicinity of the grave:

V-63, 8155 ± 130 B.P. (Fig. 3, 2). Redistributed charcoal (not burnt *in situ*) from about 3·5 in. above the top of the grave, R.L. 59 ft 4 in., and about 1 ft 9 in. W. of the foot of it.

V-65, 8155 ± 130 B.P. (Fig. 3, 2). Charcoal collected from a large mass of wood burnt *in situ*, apparently tree roots, at R.L. 54 ft 9 in., about 4 ft 3 in. below the top of the grave and 2 ft E. of it.

V-64, 8990 ± 150 B.P. (Fig. 3, 3). Redistributed charcoal from about 4 in. below the top of the grave, R.L. 58 ft 9 in. and about 2 ft W. of it.

Sample V-64 was stratigraphically earlier than the grave, and indicates the age of the upper part of the deposit into which the grave was dug.

The identity of the dates of samples V-63 and V-65, although they were from positions 4 ft 9 in. apart vertically, confirms the supposition that the grave was on or adjacent to the sloping margin of the terrace. Presumably the tree from which sample V-65 came, grew upon this slope, and sample V-63 came from a position further up the same sloping surface. The date 8155 ± 130 B.P. is thus the date of the burning which took place on this sloping surface. That the burning was prior to the burial is confirmed by the fact that burnt earthy material was used in the filling of the grave. For further radiocarbon dates, see paper by Bowler (This *Memoir*).

Explanation of Plate

PLATE 1

The Green Gully burial as excavated. Upper photo—view from above. Lower photo—view from side.

ALLUVIAL TERRACES IN THE MARIBYRNONG VALLEY NEAR KEILOR, VICTORIA

By J. M. Bowler

Department of Biogeography and Geomorphology, Research School of Pacific Studies, Australian National University, Canberra

Abstract

Examination of alluvial stratigraphy from soil pit exposures, excavations, and cores has been combined with a topographic survey, textural and radiocarbon analyses to provide a detailed account of the late Pleistocene to Holocene river terraces and the climatic environments which controlled them.

Sediments of the Keilor terrace in which human remains were located at Green Gully are fine-textured throughout. This, combined with evidence of horizontal ground-surface development through most of the terrace history, points to vertical flood-plain aggradation by deposition from overbank flow in a suspended load regime, rather than from bed-load or point-bar deposits. The stratigraphic relationships between terrace contacts are considerably more complex than a normal cut-and-fill sequence. Where channel incision has occurred into older terrace sediments, slumping and colluviation have formed an additional sedimentary unit with soil developed on it, separating the older from the younger alluvial fill. In the case of the Keilor terrace, younger alluvium has overtopped it, depositing a thin cover of sediment, burying the terrace soil and the colluvial deposit at the terrace margin.

Radiocarbon analyses place the deposition of the Arundel alluvium before 31,000 B.P. This terrace was eroded from 31,000 to about 16,000 B.P. corresponding to the main temperature lowering during the last glacial maximum. Major aggradation of the Keilor terrace extended from approximately 15,000 B.P. to about 12,000 B.P. when floodplain sedimentation became infrequent permitting soil formation to begin. These conditions continued until after the burial (about 6,500 B.P.) with occasional overbank deposition during infrequent high stage flow. During this period, the Keilor terrace chernozemic soil was actively forming with carbonate segregation and intense biotic activity, simultaneously with floodplain erosion by lateral stream incision. Later floodplain aggradation started about 4,500 B.P., depositing a thin cover of alluvium over the Keilor floodplain, burying the grave and forming the younger alluvial deposits including the Maribyrnong terrace.

Following the climatic-hydrologic relationships of Schumm and Langbein, the major phases of deposition are tentatively correlated with low discharge and rising temperature regimes; erosion and soil formation are attributed to high discharge and low temperature environments. Erosion during cold glacial conditions was followed by aggradation of the Keilor floodplain which accompanied rising temperatures and increased evaporation after 15,000 B.P. Red-brown earth soils formed on Arundel terrace alluvium from before 31,000 to about 15,000 B.P. corresponding to the minimal ages postulated for the formation of similar soils on the Riverine Plain in N. Victoria. The chernozemic soil of the Keilor terrace is a polygenetic profile formed by the burial of an older profile beneath younger alluvium. Black alluvial soils with minimal profile development occur on the Maribyrnong terrace the upper surface of which is approximately 2,000 years old.

The terrace stratigraphy, sediments, soils and radiocarbon data from this valley provide a detailed basis for comparison with other fluviatile sequences, and demonstrate the important effects of late Quaternary climates on the soils and surficial deposits in this non-glaciated region of SE Australia.

PART I

Introduction

The discovery of human remains in a soil pit near Keilor in August 1965 initiated an intensive archaeological and stratigraphic study of the area. Previous investigation of human occupation near Keilor had emphasized the importance of the Quaternary stratigraphy and depositional environments in this, one of the best developed river terrace sequences in Victoria. The skeletal remains were discovered by Mr D. Mahon in a soil pit near the junction between the Maribyrnong River and one of its W. tributaries, Green Gully. The pit had been excavated in terrace silts one mile downstream from the township of Keilor and two miles from the site of the Keilor cranium discovered in a similar terrace in 1940. The circumstances of the present discovery have been described elsewhere (Bowler *et al.* 1967, Casey and Darragh, *this volume*).

The site lay in a complex topographic setting in which much of the original terrace detail had been altered or destroyed by soil pit operations. To provide an understanding of the formation, chronology, and environment of human occupation of the terraces, it was necessary to reconstruct the stratigraphic detail both within the limits of the soil pit area and, in the broader context, within this part of the valley. Following a request from the Director of the National Museum of Victoria, the author agreed to undertake this aspect of the investigation in conjunction with archaeologists from the National Museum and the Australian National University.

In the interests of clarity and accessibility of data, this paper is presented in three parts. Following the Introduction (Part I), the second part is limited to those aspects of the investigation specifically related to the burial site and the context of the archaeological excavations carried out in the soil pit region. The third brings together details of the terrace sequence beyond those of immediate archaeological interest, and from a detailed chronologic and stratigraphic account, presents a discussion on the origin and environmental significance of the sequence.

Regional description

Near Keilor, the Maribyrnong River has incised its valley some 200 ft below the level of the late Tertiary to early Quaternary basalts which form the plains. It has cut through a sequence of sub-basaltic Tertiary sands, Lower Tertiary Older Basalt, to Silurian sandstones, greywackes and shales which form the basement throughout the Melbourne area. Where it is restricted by resistant lithologies, the river runs in a narrow valley with steep sides, as near the highway bridge at Keilor. Upstream from such constrictions, the river has excavated a wide valley by lateral erosion. These areas have been extensively alluviated and in them the best terrace sequences are preserved. The cranium discovered in 1940 was located within one such area upstream from Keilor. The present burial site is located in a similar section of the valley upstream from another narrow reach (Fig. 1).

Previous work and terrace identification

Following the discovery of the Keilor cranium, three main terraces were traced through the Maribyrnong Valley by Keble and Macpherson (1946) which they named in descending altitude Keilor, Braybrook and Maribyrnong. At Green Gully, a W. tributary of the Maribyrnong River (Saltwater Creek in Fig. 5, Keble and Macpherson), they recorded a fourth unnamed terrace between the Braybrook and Maribyrnong levels. A higher and older terrace, the Arundel, was subsequently recognized by Gill (1957) on the basis of topographic, soil and sedimentary characteristics. Gill reinterpreted the Braybrook terrace of Keble and Macpherson, by suggesting that the surface so identified was an erosion surface cut into sediments constituting the Keilor terrace, which he termed the Doutta Galla Silt (Gill 1953, 1957, 1962).

In the present study, the terrace levels for approximately $\frac{1}{2}$ mile upstream and downstream from the soil pit have been determined by tacheometer survey based on a Melbourne and Metropolitan Board of Works datum referred to low water at Williamstown. In Table 1, the terrace levels recognized in this survey are compared with those recorded by Keble and Macpherson.

Near Green Gully, three paired and two unpaired terraces are preserved. That in which the burial was located is developed on both sides of the river between R.L. 64-58 ft and is correlated with the Keilor terrace in which the Keilor cranium was found (Mahony 1943). This correlation is based on topographic levels and continuity of the terrace between sites, similar sediments and a characteristic soil profile developed on the terrace at both localities. The correlation has been confirmed by radiocarbon dating. Near Mahon's soil pit, three terraces are dis-

tinguished below the Keilor terrace between R.L. 53-49 ft, 47-44 ft, and 44-42 ft respectively. Two additional levels occur higher than the Keilor terrace but are not considered here in detail.

Fig. 1—Location of Maribyrnong River (incised into the Western Victorian basaltic plain near Melbourne), and of the two main archaeological sites near Keilor.

TABLE 1

Elevation of terrace levels in Maribyrnong River at junction with Green Gully

From Keble and MacPherson, Fig. 5, 1946		Present tacheometer survey	
Terrace	approx RL (ft)	Terrace	Average RL (ft)
River bed	24	River bed	23
Maribyrnong	44	GGM	44
Unnamed	54	GGL	48
Braybrook	64	GGJ	52
Keilor	72	Keilor	63
		Arundel A	76
		Arundel B	96

To avoid unwarranted assumptions in correlating with sequences previously described, an informal nomenclature has been adopted for those levels below that of the Keilor terrace. The following names have been allocated to these terraces in order from highest to lowest: Green Gully J (GGJ), Green Gully L (GGL), and Green Gully M (GGM).

Since the Keilor terrace identified in the present survey is in reality equivalent to the type locality of that terrace defined by Keble and Macpherson at the original skull site, these authors appear to have surveyed the Arundel level (near 76 ft) at Green Gully and correlated this with the Keilor terrace. Their Braybrook level is therefore equivalent to Keilor, and their unnamed terrace equates with the Braybrook. These levels are identical, within the limits of accuracy, with those surveyed near Mahon's soil pit.

In the present survey, the level GGL is more extensively developed than GGM. In all probability it was the GGL surface which was levelled by Keble and Macpherson and would be equivalent to their Maribyrnong terrace even though this involves a difference of four feet between the surveyed levels. The surface of GGM is represented by a small area on the right bank of the river near the soil pit, and was not recorded by Keble and Macpherson, or if surveyed by them, it was included with the Maribyrnong terrace. However, different soils and sediments establish these two levels as representing two distinct phases of deposition. This interpretation also removes an apparent anomaly in Keble and Macpherson's figure 5, in which the unnamed terrace begins at Green Gully junction and continues downstream, but which has no upstream extension. On the interpretation above, this terrace would be equivalent to their Braybrook, which they identified further upstream and incorrectly correlated at Green Gully with the Keilor level.

Gill (1953, 1957) has equated the sediments of the Braybrook terrace with those of the Keilor terrace. Both are said to have identical sediments, diastem and soils, although there is a slight difference in elevation (Gill 1957 p. 2). The sediments of these terraces have been formally defined as the Doutta Galla Silt, for which the type locality is located at the Dry Creek section (Gill 1962). The Braybrook terrace of Keble and Macpherson is regarded by Gill as an erosion surface cut into sediments of the Keilor terrace, but since no evidence to vindicate this interpretation has been published it should not be assumed that every surface so named by Keble and Macpherson has in fact originated in this manner. They recognized the continuity of the Braybrook surface along the Maribyrnong Valley at Green Gully although, as indicated above, they miscorrelated the levels at this site. Detailed examination at Green Gully has failed to produce evidence of a terrace surface having been produced by erosion into the Doutta Galla Silts. In fact, the evidence cited below demonstrates that each terrace surface corresponds to a phase of deposition and is separated from its neighbour by an erosional disconformity. While Gill's explanation of the Braybrook terrace may be valid in some parts of the valley, it does not provide a satisfactory working hypothesis in the context of the Green Gully soil pit. All the sediments within the pit would, within Gill's lithological definition, belong to the Doutta Galla Silt despite the soils, disconformities and unconformities developed within them (see p. 28).

To avoid a multiplicity of names in the discussion which follows, a procedure has been adopted in which the sediment relating to any particular terrace is referred to as 'sediment of terrace X' or 'X terrace sediment'. Thus the Keilor terrace sediment may or may not be differentiated from sediment of terrace GGJ depending on their stratigraphic and lithological relationships. This use of informal nomenclature is advocated until such time as the continuity and limitations of the units recognized here have been further defined. A stratigraphic code for the

description and erection of formal units in unconsolidated Quaternary alluvial deposits presents additional and difficult problems which will not be dealt with here.

PART II

Stratigraphy of Green Gully Burial Site

The original terrace surfaces had been considerably altered by cultivation on the E. side of the river and by the soil pit operations on the W. These alterations and excavations had in places exposed the stratigraphy to examination, but in so doing had sometimes destroyed the original continuity of stratigraphic horizons. Reconstructions of both the terrace topography and stratigraphic relationships were therefore a necessary first step in deducing the stratigraphic history and chronology of the terrace sequence and the environmental factors controlling it.

Aerial photographs, taken in 1956 before the pit was opened, permitted reconstruction of most of the terrace detail in the immediate vicinity of the pit and on the opposite side of the river, later altered by cultivation. In addition, a survey of the soil pit area was carried out by Garner and Associates in 1962, before bulldozing commenced. Garner's original pegs were relocated and, with the original plan and sections, these facilitated the reconstructions of the topographic surface. One surveyed line passed almost directly over the burial site, allowing its position to be fixed relative to the original contact between terrace surfaces. By using these independent lines of evidence, the plan and levels of the undisturbed terrace surfaces have been reconstructed as shown in Figs. 2 and 3.

Stratigraphic units

The August 1965 outline of the soil pit at the contact between the terraces is shown in Fig. 4. Sediments of the Keilor terrace were exposed on the W. and SW. sides while the NW. sides were cut in sediments of terrace GGJ. Five soil-sedimentary zones were differentiated:

1. Sediment of Keilor terrace unaltered by soil profile development
2. The soil profile zone of the Keilor terrace (top 9-10 ft)
3. Sediments of terrace GGJ unaltered by pedogenesis
4. The soil profile zone of terrace GGJ (top 6-7 ft)
5. An indeterminate zone exhibiting both pedological and sedimentary features, and located between 1 and 3 above. This is referred to here as the *intermediate zone.*

The approximate distribution of the zones is indicated in the block diagram (Fig. 4).

Keilor terrace sediment

Basal gravels three to four feet thick (basalt, sandstone, quartzite and mudstone) passed up through two to three feet of medium to fine quartz sands to 20 ft of yellowish brown to dark grey very fine sands and silts which form the main body of the terrace. Primary depositional structures were virtually absent but traces of original depositional surfaces were preserved in the lower zone of the terrace sediment. At R.L. 42 ft a band of pink oxidized silt two to four inches thick with pellets of charcoal was traced in excavation, in auger holes, and in outcrop on the pit floor, varying in elevation only six inches over a lateral distance of 30-40 ft. This indicated a grass or forest fire of high intensity on a near-horizontal floodplain surface later sealed beneath younger alluvium.

Overlying this at R.L. 44 ft, a second horizontal surface was evident as a zone of yellowish brown silts with weakly developed prismatic cleavage. It main-

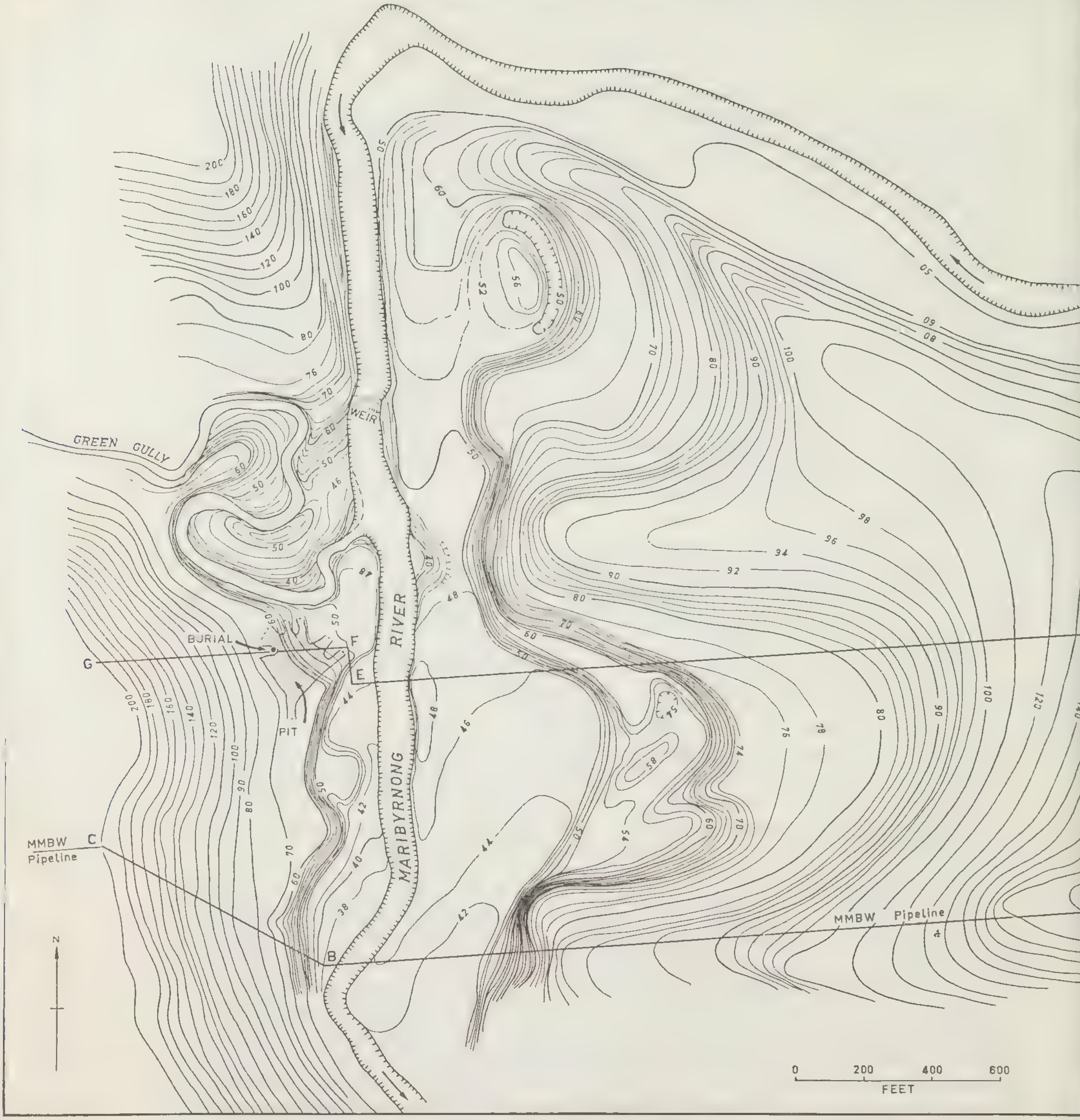


Fig. 2—Contour plan of Maribyrnong Valley near junction with Green Gully tributary showing burial site, relationship with terraces and location of the Melbourne and Metropolitan Board of Works pipeline. Levels from Melbourne Metropolitan Area Base Map Series, sheet 146, and from detailed tacheometer survey of terrace surfaces by author, August 1965. The contour interval changes from 2 ft below 100 ft to 5 ft above 100 ft. All levels in figures and text are referred to Low Water Mean at Williamstown.

tained an E-W horizontal attitude for more than 20 ft and coincided with a weak textural change, being overlain by medium to fine sands slightly coarser than the silts in which cleavage had developed. This weakly developed soil registered a

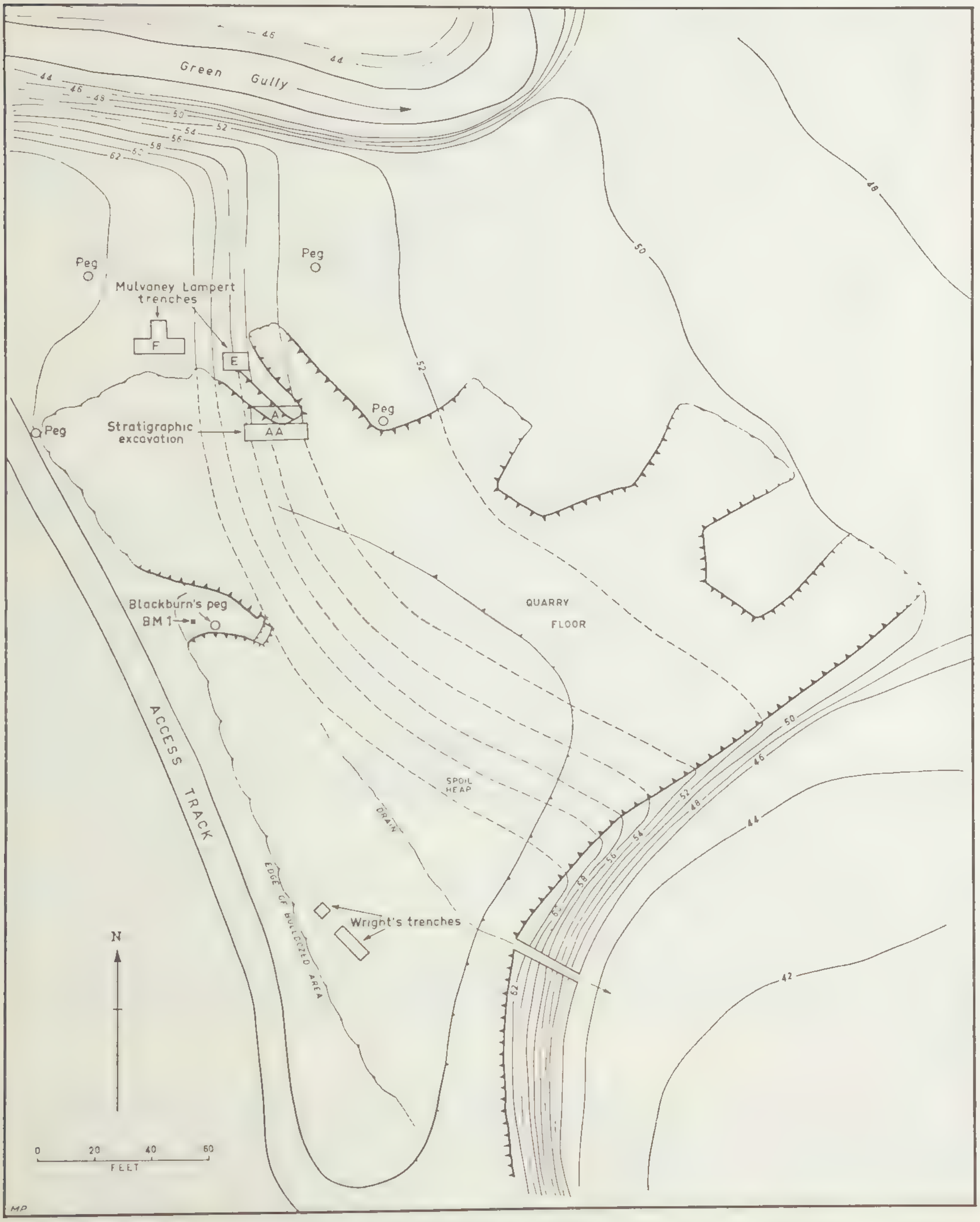


Fig. 3—Contour plan and outlines of Mahon's soil pit showing location of excavations in December 1965. Contours of original terrace surface (dashed lines), reconstructed from aerial photographs and survey by Garner and Associates, demonstrate proximity of burial to undisturbed terrace contacts.

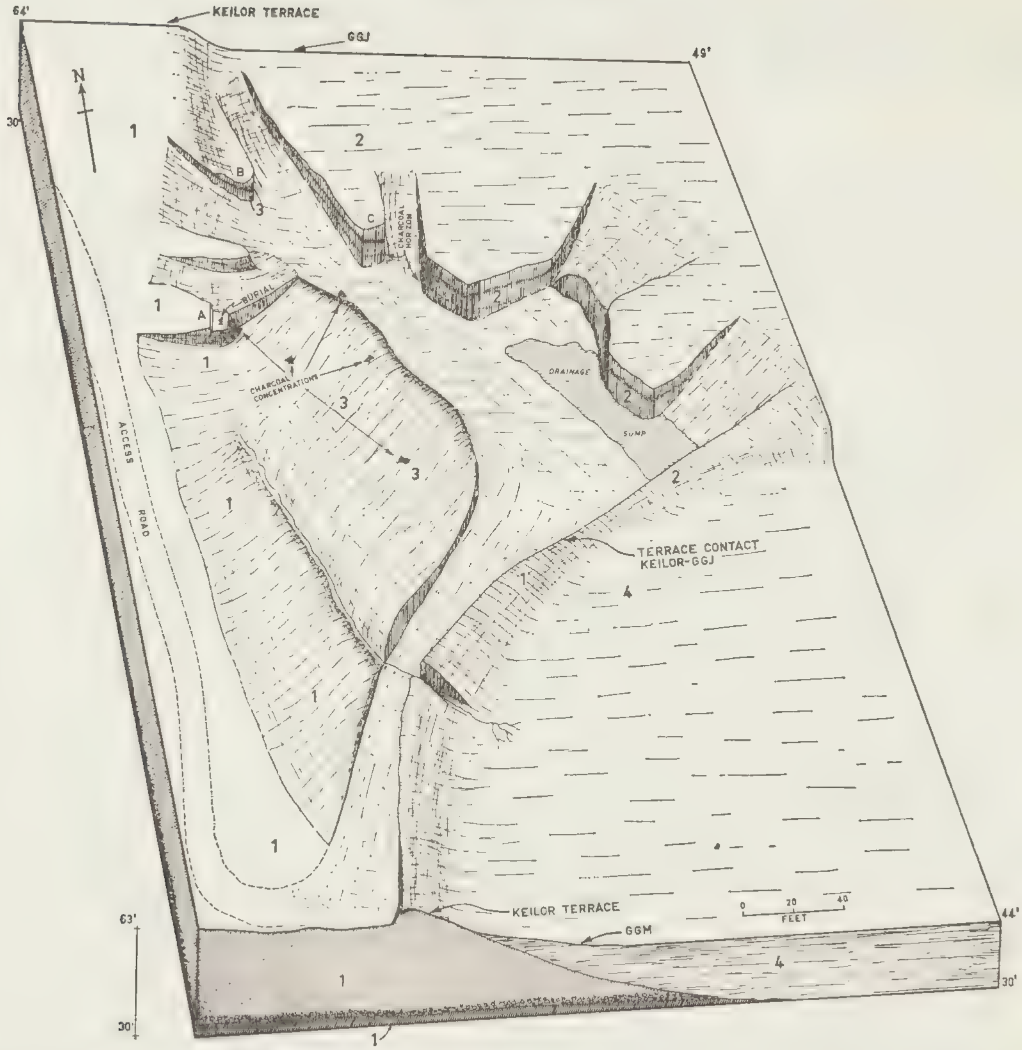


Fig. 4—Block diagram showing the outlines of Mahon's soil pit in August, 1965. Numerals 1 to 4 refer to Keilor terrace, terrace GGJ, intermediate zone and terrace GGM respectively.

hiatus in the deposition of the terrace only six feet above the level of the basal gravel. These examples provided evidence of the early groundsurface configuration and assisted in reconstructing the depositional processes.

Keilor terrace soil

A deeply differentiated soil has developed on silts of the Keilor terrace with profile features extending 9-10 ft below the surface. Although undifferentiated in terms of texture and colour, changes in degree of organization and carbonate accumulation through the profile help divide it into two main zones—an upper non-calcareous, weakly organized zone, extending down to approximately 30 in., over a lower calcareous and more highly organized zone with biotic casts and tubules. Carbonate occurs from approximately 40 in. to near 9 ft in the profile both as fine filaments (pseudo-mycelia) or linings on the surface of peds, voids and tubules, and also as near-vertical pencil-thick concretions.

Infilled worm tubes or biotic casts occur from 30 in. to approximately eight feet. These are approximately ¼ in. diameter and rarely extend in depth for more than 10 in. They are associated with a second type of larger casts of unknown origin. The latter occur as internal infillings of dark grey silts and form weakly cemented cylindrical concretions, nearly vertical in attitude and more indurated than the sediment in which they occur. They are approximately 0·7-1 in. in diameter and have been traced continuously in the profile for up to 2 ft but are usually approximately 10-13 in. long. From their orientation and the absence of branching or bifurcating structure, they are regarded as infilled burrows rather than traces of roots. They are absent in terrace sediments younger than the Keilor terrace although some were observed in the marginal or intermediate zone between the deposits of the Keilor terrace and GGJ. In size and attitude, they resemble structures formed by the infilling of holes excavated by fresh-water crustacea. They are referred to here as *large biotic casts.*

In its general profile characteristics, dark colour, alkaline pH, carbonate concretions, prismatic cleavage and depth of organization, the Keilor terrace soil resembles a chernozem—a soil type rarely found in Australia.

Sediments of terrace GGJ

Basal gravels of this terrace (basalt, quartzite and mudstone) were located in auger holes approximately five feet below the floor of the pit and in outcrop on the S. side of Green Gully some 50 ft N. of the pit. These grade up through four to five feet of medium coarse sands often containing charcoal, to an upper 10-12 ft of fine sands and silts. Although texturally they resemble the Keilor terrace sediment, they differ significantly by containing more coarse sand.

Within this terrace, horizons one to two feet thick of dark grey to yellowish brown fine sands and silts sometimes alternated, forming diffuse bedding or banding. These dipped easterly up to 17° off the contact zone with the Keilor terrace. The bedding, however, was too diffuse to define precisely the stratigraphic relationships between the various units in the irregular exposures of the pit.

Soil profile of terrace GGJ

The upper five to six feet of sediment was affected by weak pedogenesis shown mainly by the dark humic surface soil (black to very dark grey) grading to dark grey and greyish brown in depth. As in the Keilor terrace, soil textures were virtually uniform throughout the profile. Cleavage in the top 3-4 ft produced coarse prisms 2-3 in. in cross-section, in contrast to the fine 'bladed' prisms approximately ½ in. thick which occurred down to depths of 8-9 ft in the Keilor terrace. Evidence of biotic activity occurred as a minor feature only, while the large biotic casts of the Keilor terrace were absent. Carbonate was absent throughout although pH remained alkaline in all but the top few inches. The profile resembles that of a prairie or minimal prairie soil (cf. Stace *et al.* 1968).

Intermediate zone between GGJ and Keilor terrace

On the N. side of the soil pit (peninsula B, Fig. 4) diffuse bedding within sediments of GGJ dipped E., aproximately parallel to the topographic surface at the terrace contacts. One such band of dipping medium to fine sands overlay a darker grey zone in which evidence of weak pedogenesis was shown by:

1. Aggregation of sediments to produce weak pedal structure
2. weakly developed prismatic cleavage and
3. evidence of biotic activity in the presence of both small infilled tubules and large biotic casts similar to those found in the Keilor terrace soil.

This zone resembled the Keilor terrace soil in both colour and texture but occurred at a lower level, being found down to the floor of the pit (R.L. 41 ft).

Dark grey sediment with pedal development, abundant charcoal, and often associated with pink oxidized sediment, outcropped on the floor some 10 yards east of the burial site and continued north to the peninsula B as described above. This appeared as part of the same zone localized near or along the topographic junction between the two terraces. The zone was initially regarded as one of weak pedogenesis developed on a groundsurface formed by erosion in the Keilor terrace before deposition of the younger terrace GGJ. The situation however proved to be more complex than this.

From peninsula B to C (Fig. 4) a thin but extensive horizon of charcoal and pellets of pink oxidized silts were traced laterally for more than 20 ft. These were distributed along an apparent bedding plane within the pedogenetic intermediate zone. The horizon was located approximately 18 in. below the disconformable contact with GGJ, and dipped E. conformably with it suggesting the presence of a bedded unit within what was apparently a zone of soil formation. In addition, while this zone contained no *in situ* carbonate, some concretions were found in horizontal or random orientation indicating deposition following erosion of an older calcareous profile (Fig. 5). Thus, what was regarded initially as a buried soil, contained elements of depositional structures unlike those of either the Keilor or GGJ terrace sediments.

Evidence of fires

Within the pit, concentrations of charcoal enclosed within zones of hard brick-red oxidized silt recorded the effects of oxidation and baking by *in situ* fires. These zones up to five feet across, were usually located near the terrace contacts associated with the dark grey pedogenetic zone with pedal structure and biotic casts. They thus appeared to belong to the intermediate zone described above.

Five concentrations of charcoal and oxidized silt were excavated on the floor of the pit some 20 yards E. and NE. from the burial site. Three of these possessed circular outlines up to 3 ft 6 in. diameter with near-vertical sides extending in depth for more than 3 ft, and sometimes branching laterally in the manner of tree roots. Fibrous structures of charcoal often retained an orientation parallel to the oxidized margins. These zones could only be explained by the burning of large trees in position of growth. Two other such excavated zones had little extension in depth and were formed by burning of horizontal logs.

The downward intrusion of fires into underlying sediment by burning of roots is similar to that known to occur during the burning of stumps in the clearing of eucalypt forests to this day. By covering a burning stump with soil in a process known as 'stoving', farmers commonly keep roots smouldering underground for many days. This produces a partially evacuated zone of ash and charcoal into which soil later collapses. In a case known to the author, a child who fell through surface soil into a space created by recent sub-surface burning of roots, suffered burns up to the waist, indicating an underground zone of burning at least 2 ft 6 in. to 3 ft deep, consistent with the downward extensions of oxidized earth found in the pit. Evidence of similar collapse was found in the disturbance of normally vertical tubules and biotic casts within several of the excavations.

Relationship of burial to soil-sedimentary zones

The burial was located in dark grey silts within the zone of soil profile development of the Keilor terrace. Evidence of pedogenesis in weak pedality, and traces of vertical cleavage in the soil above the remains, confirmed their considerable antiquity. As shown in the detailed report of the burial excavation (Casey and

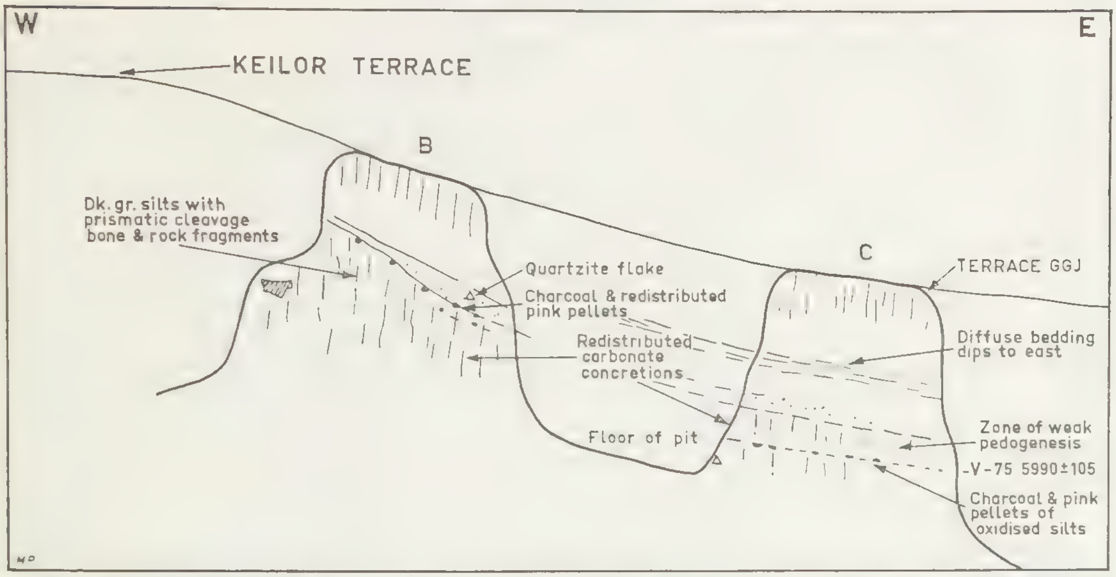


Fig. 5—Section in soil pit showing stratigraphy exposed on peninsulas B and C (Fig. 4) relative to terrace surfaces.

Darragh, *this volume*) the deposits contained little evidence of stratigraphic layering above or near the burial. The archaeological excavation went down through homogeneous deposits of dark grey silts or clayey silts from the surface (R.L. 62·5) down to R.L. 59 ft uncovering occasional quartzite flakes, basaltic fragments and boulders presumably transported by human origin. At R. L. 59 ft, spit 10 in the excavation, a slight change in soil consistency and colour occurred and extended down to the level of the burial. This zone was slightly red in colour due to the admixture of oxidized silts with dark grey unaltered sediment around and above the body. The mixing within the burial zone indicated the use of oxidized earth to partly fill the grave. The bones themselves showed no evidence of burning (Macintosh 1967) and had therefore been interred after the fires which caused the burning, oxidation and local development of charcoal.

Casey and Darragh have established the upper limit of this zone at R.L. 59 ft, i.e., 3 ft 6 in. below the upper level of the terrace surface. This indicates that a grave had been dug from a surface near R.L. 59 ft and later covered by 3 ft 6 in. of alluvium. The fires with which the burial was associated were therefore older than the surface from which the grave was dug. Subsequent excavations by Mulvaney (*this volume*) established the upper limit of *in situ* burnt and oxidized silts in the terrace at about R.L. 58 ft 3 in., i.e., only 9 in. below the burial, and 51 in. below the present topographic surface of the terrace. Almost all the massive concentrations of charcoal and oxidized silts within the soil pit occurred in the pedologically altered intermediate zone, except those below the burial which had extended down into unaltered Keilor terrace silts. In this respect the zone of burning near the burial differed from those described earlier.

Large biotic casts occurred below the level of the human remains but not in the zone above. The zone of maximum carbonate concentration was also located only a few inches below the level of the burial although some carbonate was encrusted on part of the remains (Macintosh 1967). The main period of carbonate mobilization probably occurred before the interment, but some carbonate was still mobile for a short time after the burial.

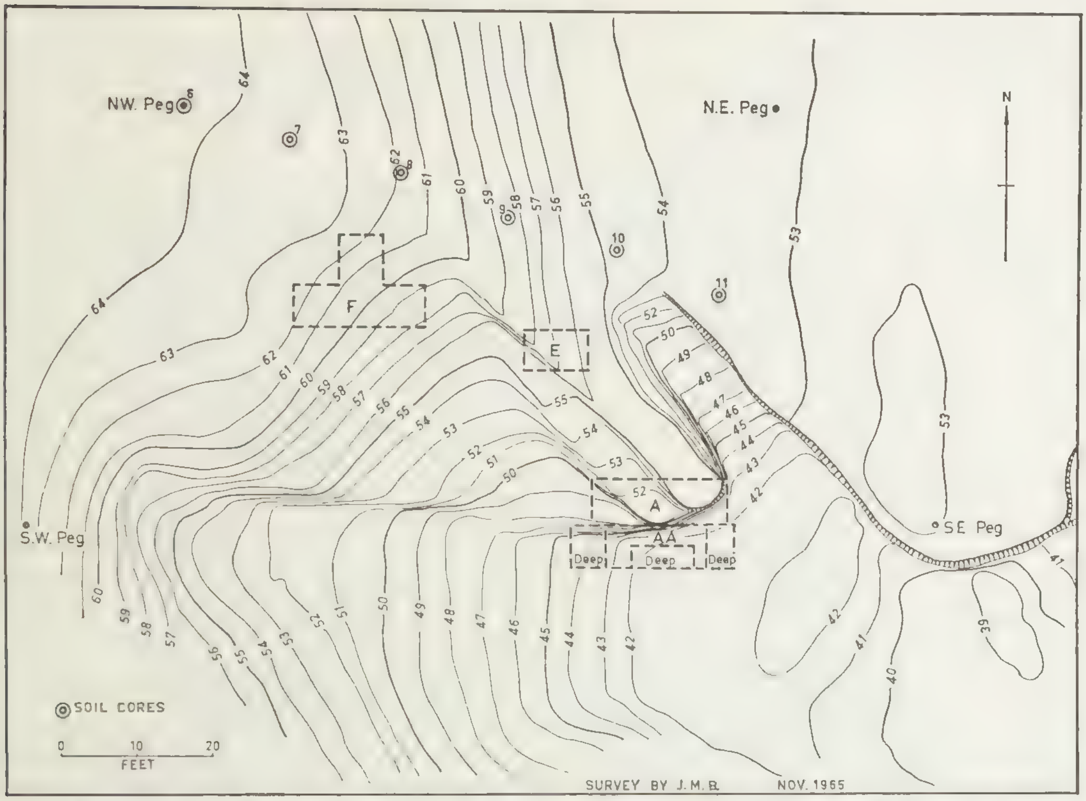


Fig. 6—Detailed plan of N. part of soil pit near peninsula B in December 1965, showing sites and levels of excavation and soil cores.

The dark grey silts of the intermediate zone therefore represented a separate sedimentary unit rather than a simple soil profile. From the similarity in textures and from the spatial distribution of this zone, it could only have originated from erosion and redeposition of Keilor terrace sediment along a steep cliff corresponding to the edge of a channel cut into the older terrace. Sediment which accumulated along the foot of this cliff remained stable long enough to permit a small degree of profile development before the later deposition of alluvium of terrace GGJ. Sediments of this unit comprise the intermediate zone whose presence had been suspected from evidence elsewhere within the soil pit. The recognition of this separate sedimentary unit explained the concentration of flakes, bone and charcoal in the lower levels of the excavation and their relative absence in older sediments of the Keilor terrace at an equivalent level only a few feet to the W.

The lower and upper limits of the intermediate zone were set by (1) the colour change and traces of bedding near the contact between the dark grey silts and the yellowish brown silts in the base of the stratigraphic excavation, and (2) by the upper limit of pedogenetic development between R.L. 49-52 ft as shown in Fig. 7.

The excavation not only established the disconformable relationships between the Keilor and GGJ terraces, but demonstrated the existence of two disconformities where only one had been anticipated. These delineated the zone of redistributed sediment derived by erosion from the Keilor terrace. This further explained the occurrence of reworked carbonate concretions within this zone and at the base of peninsula C, Fig. 5. They were derived by erosion from the soil profile developed earlier within the Keilor terrace.

Stratigraphic Excavation

An understanding of the ages and environmental origins of the soils and sedimentary facies, including those immediately adjacent to the burial area, was essential to clarify both the archaeology and geomorphology of the area. An investigation was therefore undertaken to establish the stratigraphic relationships in an undisturbed area, to evaluate their importance in the environmental history, and to relate them to the history of the human remains.

At the undisturbed contact between terraces on the N. side of the pit, the intermediate zone was represented with other units, and was therefore selected for detailed examination. An excavation here in December 1965 was jointly supervised by the author in co-operation with D. J. Mulvaney and R. J. Lampert of the Australian National University, who took responsibility for the archaeological data. Information on this aspect of the excavation is provided by Mulvaney (*this volume*). Much of the data in this report has been derived from that excavation, which for convenience and to distinguish it from the more specifically archaeological excavations, is hereafter referred to as *the stratigraphic excavation*.

An E-W. base-line 120 ft long was marked out along which a trench 20 ft long and 6 ft wide was opened on the S. end of peninsula B (excavation A in Fig. 6). The floor of the trench was lowered in 3 to 4 inch spits while the spoil was thrown onto the quarry floor and later bulldozed away. The excavation passed through 4 ft of upper fine sandy sediment of terrace GGJ into a zone of dark grey silts with weak pedality and prismatic cleavage. Quartzite flakes, bone and charcoal fragments occurred rarely in the upper GGJ sediment but were more frequent in the underlying pedological zone.

During later cleaning of the spoil from around the end of the peninsula, the bulldozer exposed a concentration of charcoal and oxidized silts with a quartzite flake 5 in. below the quarry floor at R.L. 40·5 ft near the S. side of the excavation. In view of the possible significance of an artifact at this level, 23 ft below the surface of the Keilor terrace, and the need to examine the stratigraphy at a level normally unexposed within the terrace, the excavation was extended by opening a pit (AA in Fig. 6) 24 ft long on the quarry floor 6 ft S. of and adjacent to the level of the first excavation (see Plate 2). Work was concentrated on the lower level below 41 ft, in an attempt to establish the stratigraphic relationship between the artifact found here and those of the Keilor terrace.

In the lower level two different facies or zones were recognized. Dark grey silts with weak soil structure were encountered on the E. end of the trench passing to hard yellowish brown silts of the unaltered Keilor terrace in the W. Occasional artifacts, bone and charcoal occurred in the E. end of the trench in dark grey silts, but only one quartzite flake was found in the W. end in the yellowish brown silts at R.L. 40·5 ft, i.e., 23 ft below the top of the Keilor terrace.

Evidence of fire within the yellowish brown silts was found at 42·5 ft, some 2 ft above the level of the flake. This was the extensive zone of pale pink oxidized silts 2 to 4 in. thick with the fragments of charcoal as described earlier from near the basal part of the terrace. Although continuous to the W. and S. beyond the trench, this horizon did not extend to the E. through the dark grey silts on the N. side of the trench. It could be traced only half way across the face of the section as in Fig. 7.

Traces of bedding throughout the pedogenetic zone dipped to the E. away from a relatively sharp contact between the two facies exposed in the trench. The contact sloped steeply to the E., and was itself immediately overlain by an horizon with a similar E. dip containing pink oxidized silts and redistributed charcoal within the depogenetic zone. Immediately W. of the contact, within the Keilor terrace sediment, traces of original depositional surfaces were horizontal (Fig. 7).

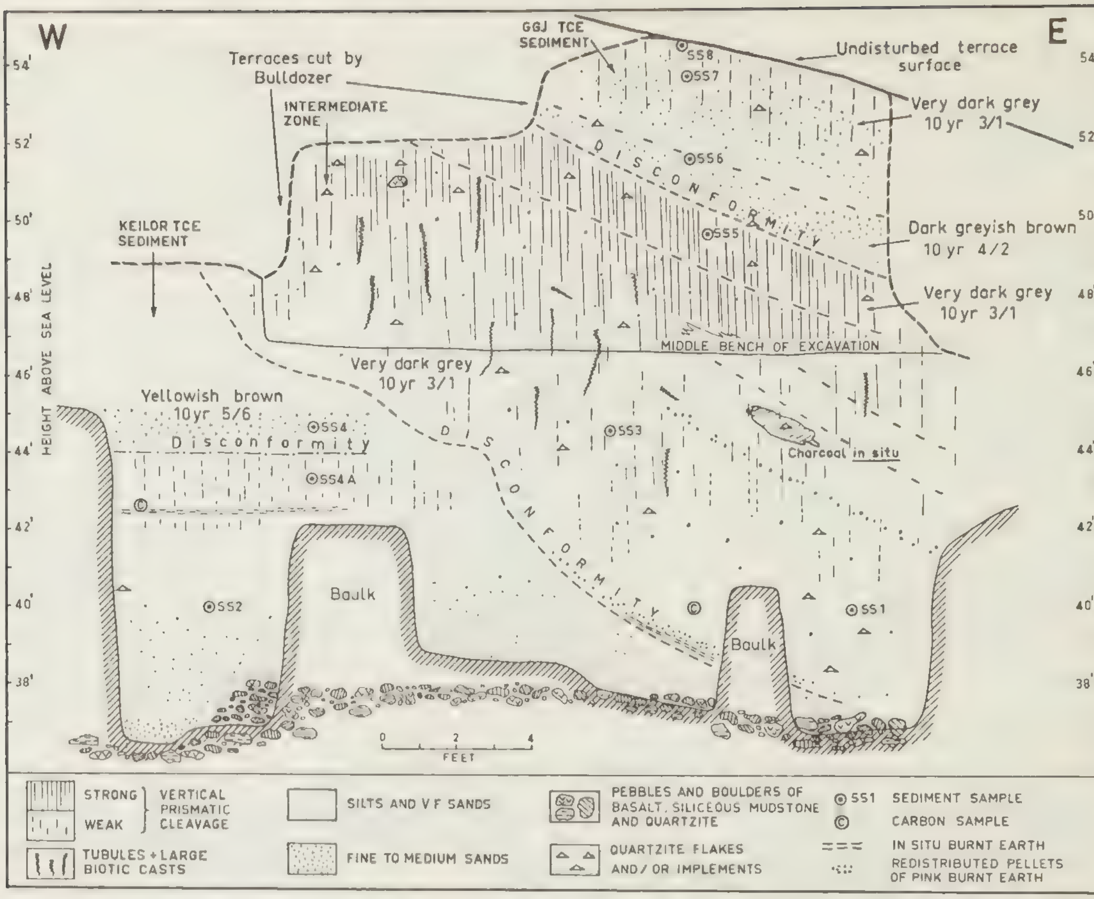


Fig. 7—Detailed section exposed during December 1965 stratigraphic excavation (trenches A and AA, Fig. 6). An intermediate zone with elements of both soil and sedimentary character separates younger dipping deposits of GGJ from older horizontal alluvium of Keilor terrace. Below the middle bench, section projected 6ft N. Section outlines from scale drawing by R. Lampert; stratigraphic details by J.M.B. See Fig. 9 for sediment analyses.

The massive concentrations of charcoal and pink oxidized silts, which occurred at various levels throughout the pit, were now seen to be localized within the intermediate zone of redistributed sediment, and located along the terrace contact. The burial overlay a zone of charcoal and brick-red silts which extended down to R.L. 52 ft and again represented the burning of a tree root in position of growth (Casey and Darragh, *this volume*). An additional excavation near the burial site, by Mulvaney in January 1966, established beyond doubt that the burnt roots intruded into undisturbed Keilor terrace sediment.

In the area affected by burning below the burial, carbonate concretions had developed around pink oxidized silts indicating concretion formation after the fires. At least two separate tree burning phases are therefore implied: one before mobilization of carbonate in the Keilor terrace profile, the other after mobilization. Fires of the latter period were those concentrated along the edge of the channel cut into the Keilor terrace corresponding in place and time to the deposition of the intermediate zone.

Laboratory Analyses

To describe more adequately the sediments and to determine the pattern of variation through the soil-sedimentary column, selected samples were analysed for texture, organic content and pH.

Textural analyses

Standard screening methods were used to size material larger than 62 microns using a BSS nest of screens in a mechanical shaker. The silt distribution (62 to 4 microns) was determined using a settling technique (hydrometer method). Clays (less than 4 microns) were not sized due to the relative unimportance of clay-size distribution for the present study. Analyses of Keilor terrace samples were carried out from three separate sites in or near the soil pit:

1. Samples from N. of the burial were selected from the stratigraphic excavation and from cores, 6, 7 and 8 (Fig. 6);
2. from the burial site and;
3. from Wright's trench S. of the burial as in Fig. 3.

Representative curves plotted on log probability scales are shown in Figs. 12 to 15. Of 42 samples analysed, 88% contained more than 50% silt, 20% contained silt in the range 70-75%, and 30% in the 50-55% silt range. The textural grades present in any one sample extended from very fine sands to clay with the largest primary sediment rarely exceeding 0·30 mm.

Although fine-textured throughout, small lateral variations were recorded between sites. The silt percentage in samples near the stratigraphic excavation averaged 50-55% increasing to 65-70% at the burial site and reaching a maximum of 74% in samples from Wright's trench, thus demonstrating a change in texture from N. to S. in the soil pit area. The apparent coarsening is due more to relative variations in the percentages of clay than to any coarsening of sands, the pattern of which remained the same throughout.

By comparison with fluviatile sediments in other areas (cf. Allen 1965) the Keilor terrace sediments display an unusual degree of vertical uniformity in texture. All samples analysed from core 7 and in the underlying sediment down to 22 ft below the surface (as in Fig. 9) fall within the size ranges—sand 21-29%, silt 47-60% and clay 20-28%. But despite the overall uniformity, small but consistent variations occur in the distribution of the coarser tails of the textural curves, which are particularly sensitive to small changes in depositional regimes (Mason and Folk 1958). These trends are shown in the distribution of material coarser than 0·20 mm, a size which has additional environmental significance for it falls close to the boundary between bedload and suspended load for a wide range of hydrologic conditions (Sundborg 1956). Material finer than 0·20 mm, i.e., almost all sediment of the Keilor terrace, is almost invariably transported as suspended load. Variations in the distribution of this fraction through the column is shown in Figs 8 and 9. SS4 in Fig. 9 represents a thin band (6 in. thick) over the zone of weak pedogenesis near R.L. 44 ft, and may give a false impression of the distribution of the coarse tail in this part of the terrace. In all sections analysed, the top 30 to 36 in. of sediment contains a small but consistently higher percentage of material coarser than 0·20 mm than occurs in sediment immediately below this zone (Figs. 8, 9 and 11).

Sediments of GGJ are likewise fine textured throughout but maintain a higher percentage of fine to medium sand than in the Keilor terrace. The fraction coarser than 0·20 mm resembles that found in the top 30 in. of the Keilor terrace but here the distribution of that fraction remains constant down the profile (Fig. 10). Of 17 samples analysed from this deposit the silt percentage of all fell within the range

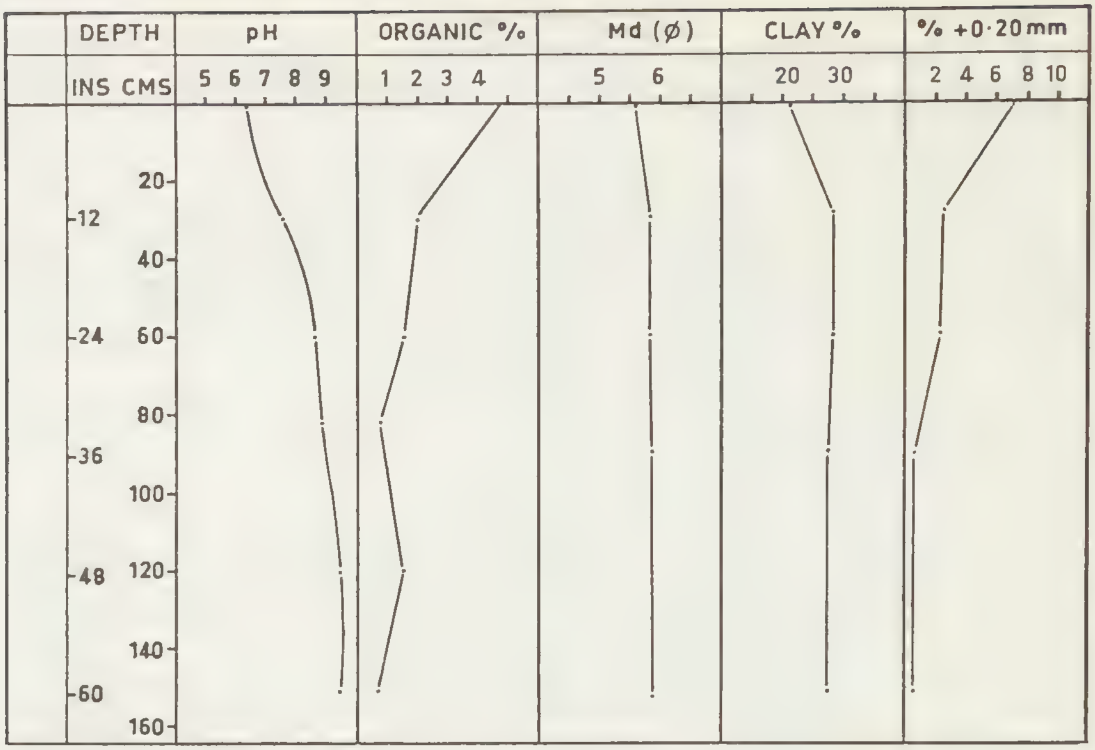


Fig. 8—Fig. 8—Depth function data through top 5 ft of Keilor terrace soil and sediment from samples at one foot intervals through core 6, Fig. 6.

45% to 55%. In the stratigraphic excavation the basal unit of this terrace represented by SS6 is considerably coarser than the overlying sediments SS7 and SS8 (Figs. 7 and 9). The coarse unit here is laterally equivalent to sediment some 10 ft below the surface of terrace GGJ as in Fig. 5. The size distributions of samples at one foot intervals through core 10 are shown in Fig. 10.

Organic content

Organic matter has been determined using hydrogen peroxide as the oxidizing medium, providing a measure of relative organic content. The distributions through Keilor terrace sediment and soil are shown in Figs. 8, 9 and 11. The organic content ranges from 5% in the top 3 in., decreasing with depth below the surface to 0·5% at 3 ft with the important occurrence of a weak buried maximum near 48 in. as shown in cores 6 and 7 (Figs. 8 and 9). The distribution in sediments of GGJ show a similar pattern falling from surface values of 5% to 1% lower in profile at 6 ft, but no secondary maxima are present. The organic content seems mainly controlled in both cases by accumulation or illuviation of material associated with the present terrace surface with the exception of the buried maximum in the Keilor terrace, which may be related to an earlier phase in the terrace history.

pH

Values were determined with a Cambridge pH Meter using a 1:5 soil-water mixture. To reduce drift by interaction with atmospheric carbon dioxide, measurements were carried out in an inert atmosphere obtained by passing a steady stream of nitrogen through the mixture while measurements were made. Values determined

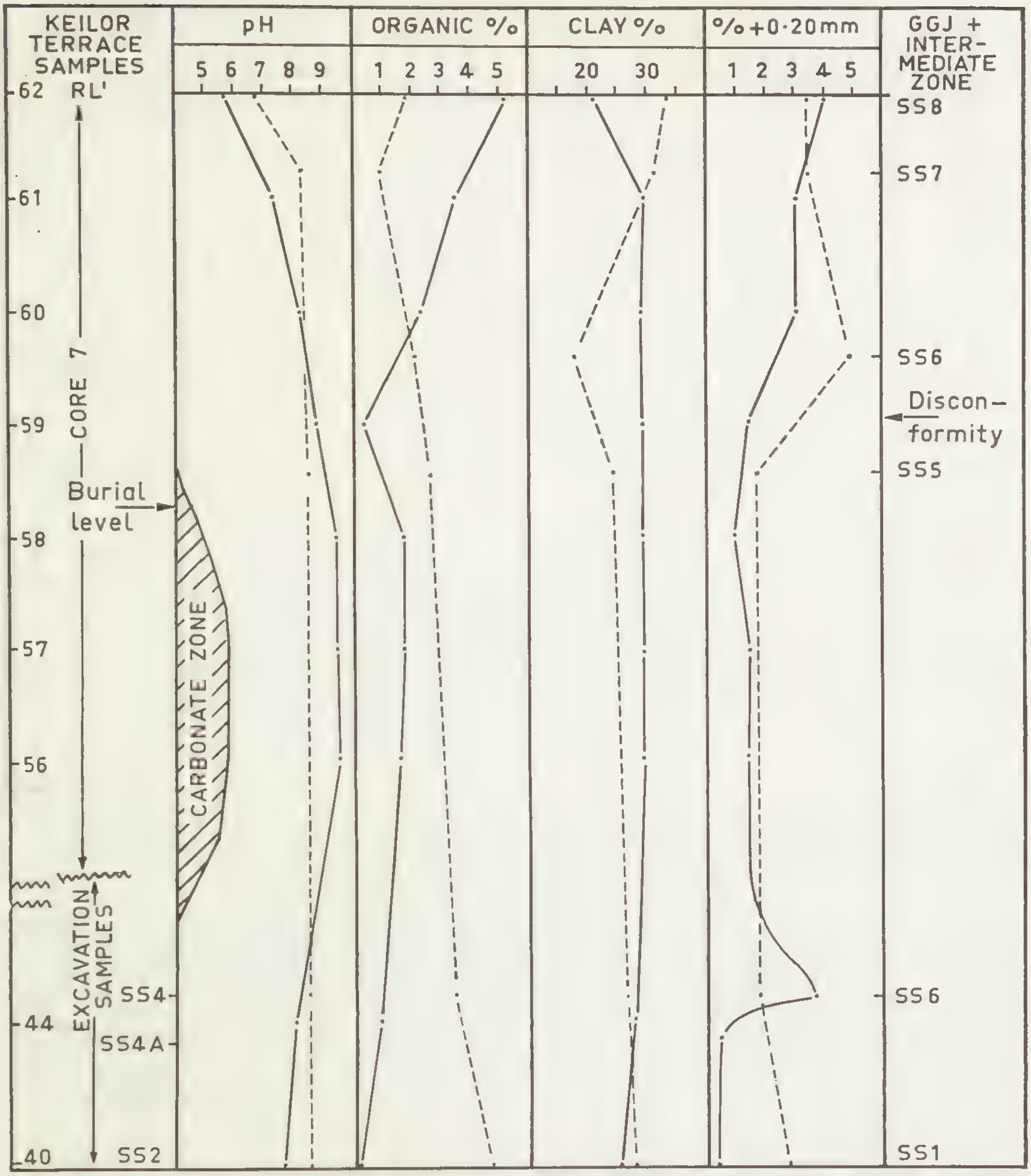


Fig. 9—Composite depth function data through Keilor terrace (full line) and through sediment of GGJ and the intermediate zone (dashed line). Keilor terrace data from core 7 (Fig. 6) and from samples SS2, 4 and 4A. All samples with prefix SS are from the stratigraphic excavation as shown in Fig. 7. Ten feet of homogeneous sediment between RL 45 ft and 55 ft in Keilor terrace are not represented. Disconformity established in field between SS5 and SS6 coincides with textural change as shown in the percentage sand coarser than 0·20 mm. A sympathetic change occurs at equivalent level in core 7 consistent with presence of disconformity also in core. Carbonate which occurs as nodules through 4 ft of core 7 is present in intermediate zone only as fine earth, filaments or redeposited nodules.

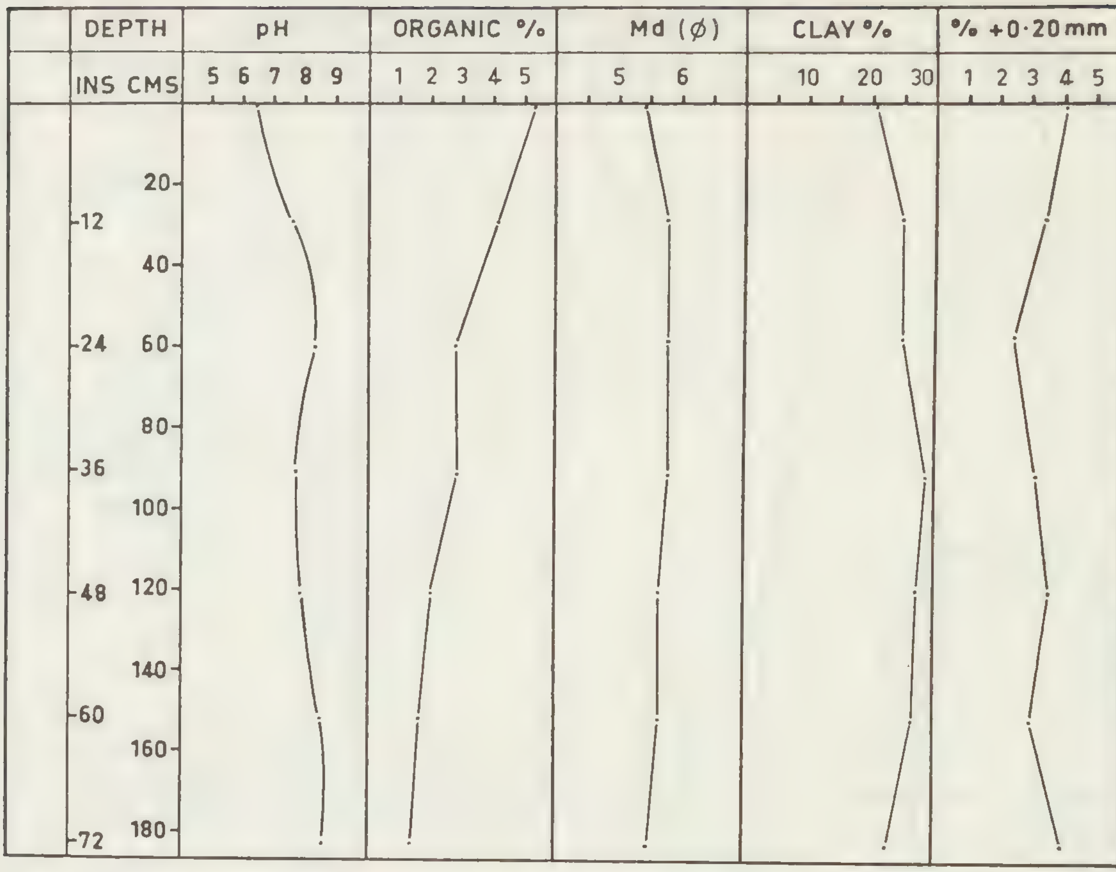


Fig. 10—Depth function data for the top 6 ft or soil and sediment of terrace GGJ from samples at one foot intervals through core 10, Fig. 6.

in this way tend to be a little higher than those made in contact with atmospheric carbon dioxide. In the Keilor terrace, pH varies from weakly acidic values in the top 3 in. increasing to alkaline values near 12 in., and further increasing in depth to values exceeding 9 near 48 in. in the zone of secondary carbonate (Figs. 8, 9, 11 and 17). In GGJ a similar pattern is evident, although the high values in excess of pH 9 are not present, presumably due to the absence of carbonate in sediment and soil of this terrace. Values remain alkaline to considerable depth as shown in Fig. 10.

Comparison between samples from terrace units and intermediate zone

Comparison between the sediments of the two main terrace units and that of the intermediate zone is best shown in the analyses of samples from the stratigraphic excavation Table 2 and Fig. 9. These show the comparison between the Keilor terrace sediment as determined from samples of core 7 and from the basal part of the terrace exposed in the stratigraphic trench with the sediment characteristics of terrace GGJ and the intermediate zone as revealed in the stratigraphic excavation. The relative position of the samples is shown in the section Fig. 7. Here the presence of the three zones separated or bounded by disconformities had been established in the field as described earlier.

The texture of samples from the intermediate zone closely resembles that of the lower part of the Keilor terrace from which it was derived. But the percentage

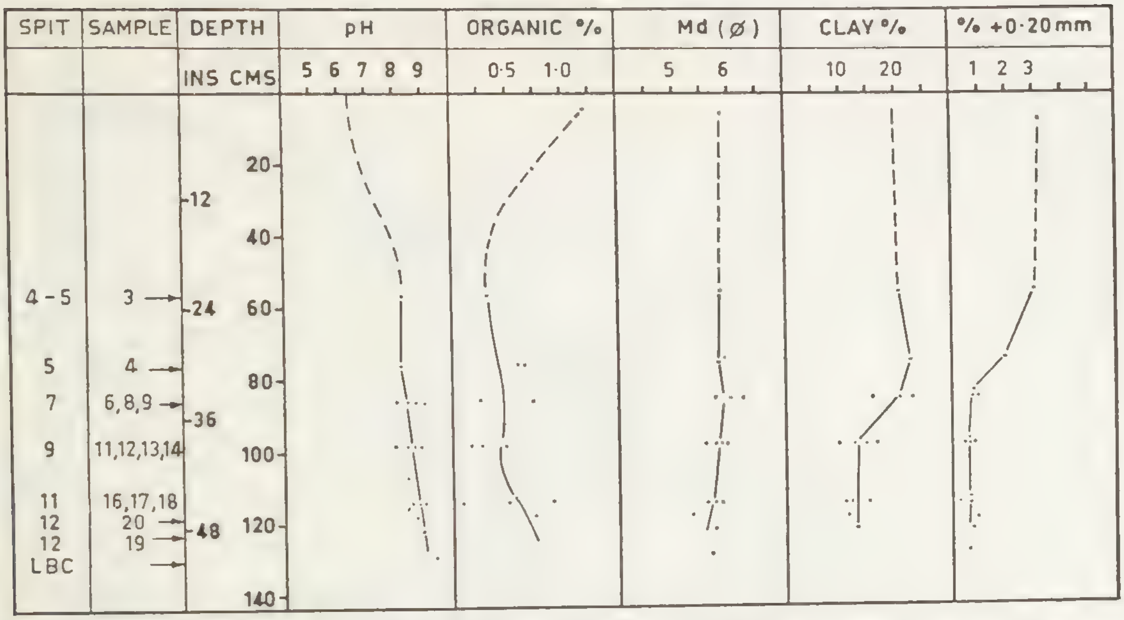


Fig. 11—Depth function data through burial excavation section. Samples are from the spit levels as excavated by Casey and Darragh. Note small but significant change in texture near spit 7 which corresponds to level of suspected disconformity (cf Fig. 17). Analyses of large biotic cast (LBC) from near burial included for comparison; material infilling tubule related to zone below spit 7, suggesting infilled from surface existing before deposition of top 30 in. of terrace sediment. This is consistent with these casts being same age or older than burial.

coarser than 0·20 mm in samples SS6, 7 and 8, representing sediment of GGJ in the stratigraphic excavation, is similar to the upper 30 in. of the Keilor terrace, suggesting a genetic relationship between the two zones. The former samples were deposited on a topographically lower site than those on the upper part of the Keilor terrace, as in the top 30 in. of core 7, and therefore would be expected to contain more sand and less clay than equivalent sediment at a higher level in a regime of overbank deposition. This is consistent with the results shown in Fig. 9 when compared to those of core 7. Thus the disconformity established in the field between samples SS6 and SS5 is also related to the sediment variations near 30 in. in cores 6 and 7.

Sediment of the intermediate zone contains slightly less clay than in core 7 as may be expected; during reworking of the older sediment the clay is most likely to be removed. This zone is also high in organic matter—another aspect of its pedological development. The textures of the intermediate zone are closely related to the analyses of the Keilor terrace below 30 in. from which material of that zone was derived. But the sediments of the overlying GGJ terrace show a consistent contrast with the underlying zones (cf. SS6 with SS5, Fig. 9). Deposition during this later phase started with relatively coarse sands of SS6 (5% material larger than 0·20 mm), and then became finer upwards through SS7 to SS8, with sand percentages ranging from 32% (SS6) through 25·5% (SS7) to 20·7% (SS8).

Carbonate

The presence of carbonate has been estimated visually in the field and checked in the laboratory by reaction to dilute hydrochloric acid. The distribution of car-

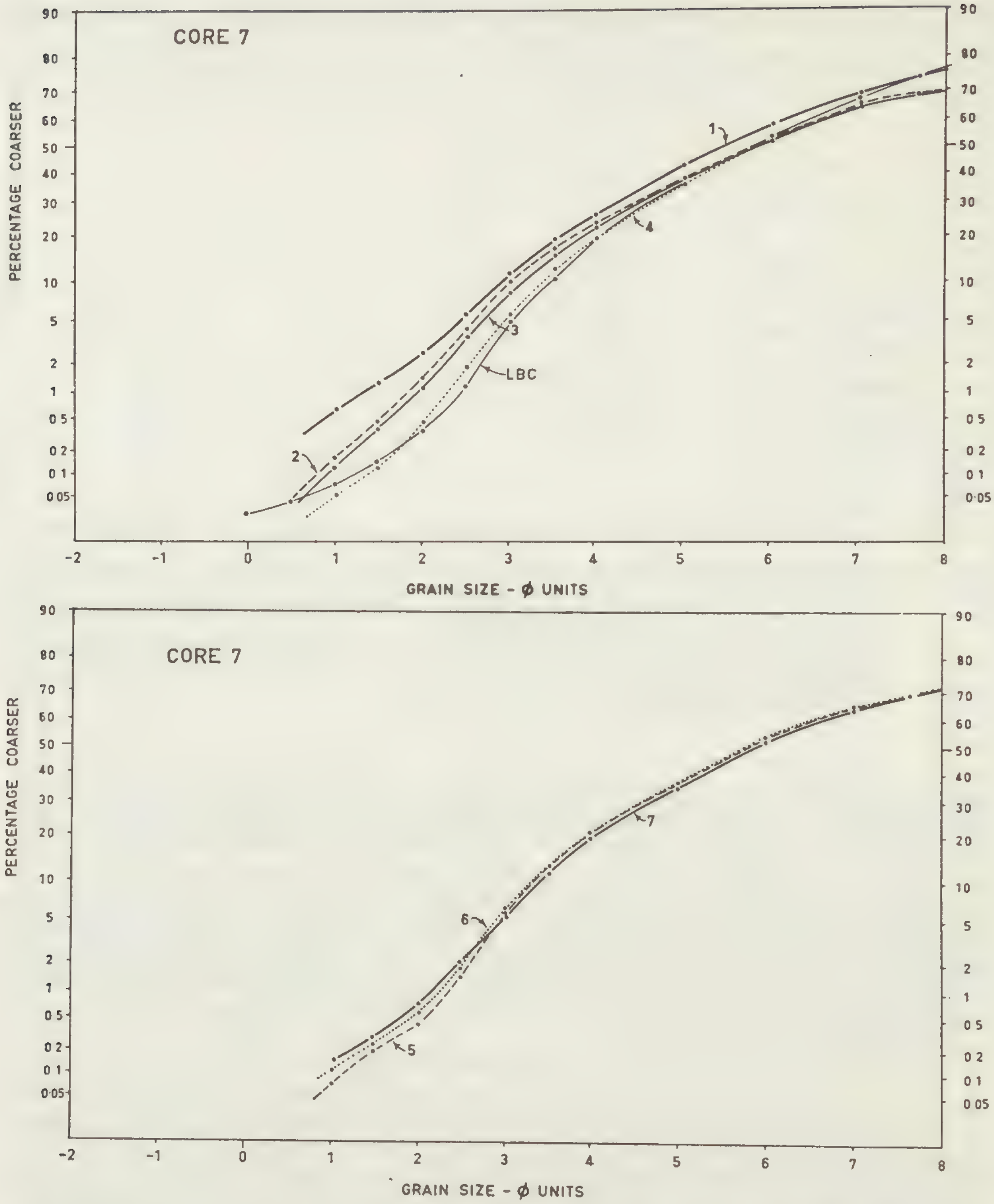


Fig. 12—Textural distribution curves of samples at one foot intervals through core 7 with curves 1 to 7 representing the top and 6 ft in cores respectively. Note homogeneity of curves below 3 ft (curves 4 to 7) and the upward coarsening towards top of core (4 to 1). The sediment infilling large biotic cast is texturally identical with lower zone in which it occurs.

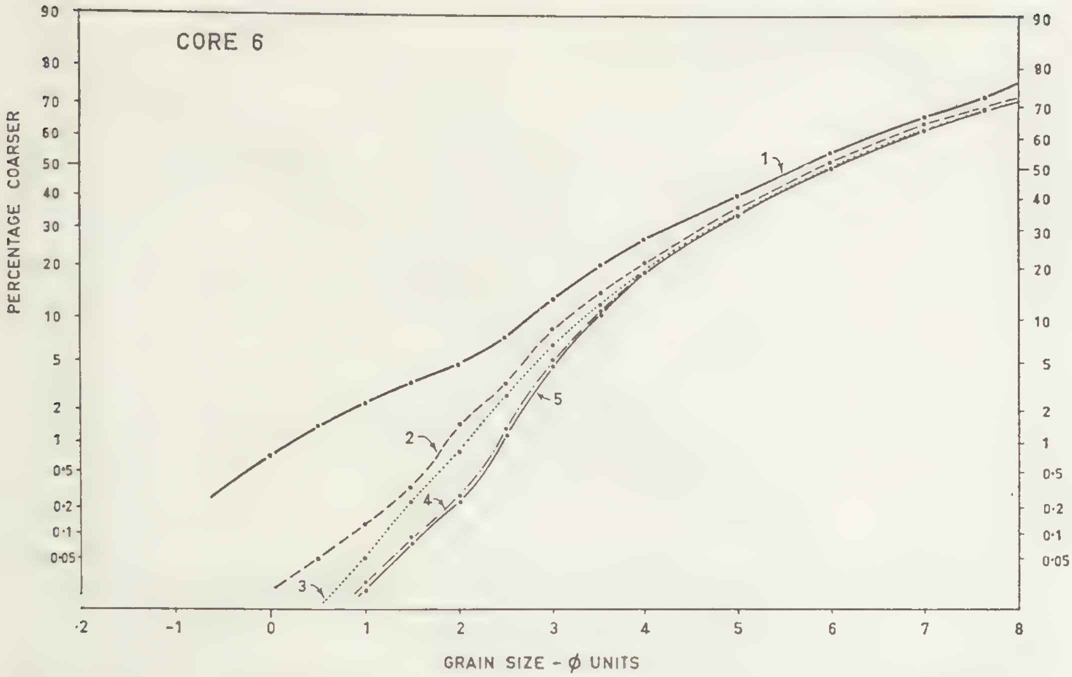


Fig. 13—Textural distribution curves of samples at one foot intervals through core 6 to show features identical with core 7, Fig. 12, emphasising lateral as well as vertical uniformity through Keilor terrace.

TABLE 2

Comparison between textures through upper 6 ft of Keilor terrace as shown in core 7 with those in section exposed by excavation AA at terrace contact (Fig. 6)

CORE 7							SECTION IN FIG. 7					
Depth (Ft)	Sample	Md ϕ	% Clay	%+0·20 mm	% Organic	pH	Sample	Md ϕ	% Clay	%+0·20 mm	% Organic	pH
0	1	5·4	21·0	4·5	5·2	5·9	SS8	5·8	29	3·2	2·0	6·8
1	2	5·7	29	3·0	3·6	7·4	SS7	5·6	27	3·5	1·0	8·2
2	3	5·7	28	3·0	2·3	8·2	SS6	5·1	16	4·9	2·2	8·3
	. . . disconformity . . . inferred								. . . disconformity . . . established			
3	4	5·7	28	1·2	0·2	8·8	SS5	5·9	22	1·6	2·7	8·7
4	5	5·7	28	0·9	1·7	9·4**						
5	6	5·7	28	1·2	1·7	9·4**						
6	7	5·8	28	1·3	1·6	9·5**						
18·5	SS4*	5·4	22	3·6	1·1	8·1						
20	SS4A	6·0	28	0·25			SS3	5·8	26	1·6	3·0	8·5
23	SS2	5·6	21	0·5	0·2	8·6	SS1	5·8	26	2·9	4·8	8·6

** Free carbonate present.

* SS4 is unusually coarse for this part of the terrace. It represents a slightly coarser band overlying the weakly developed soil horizon at 4 ft.

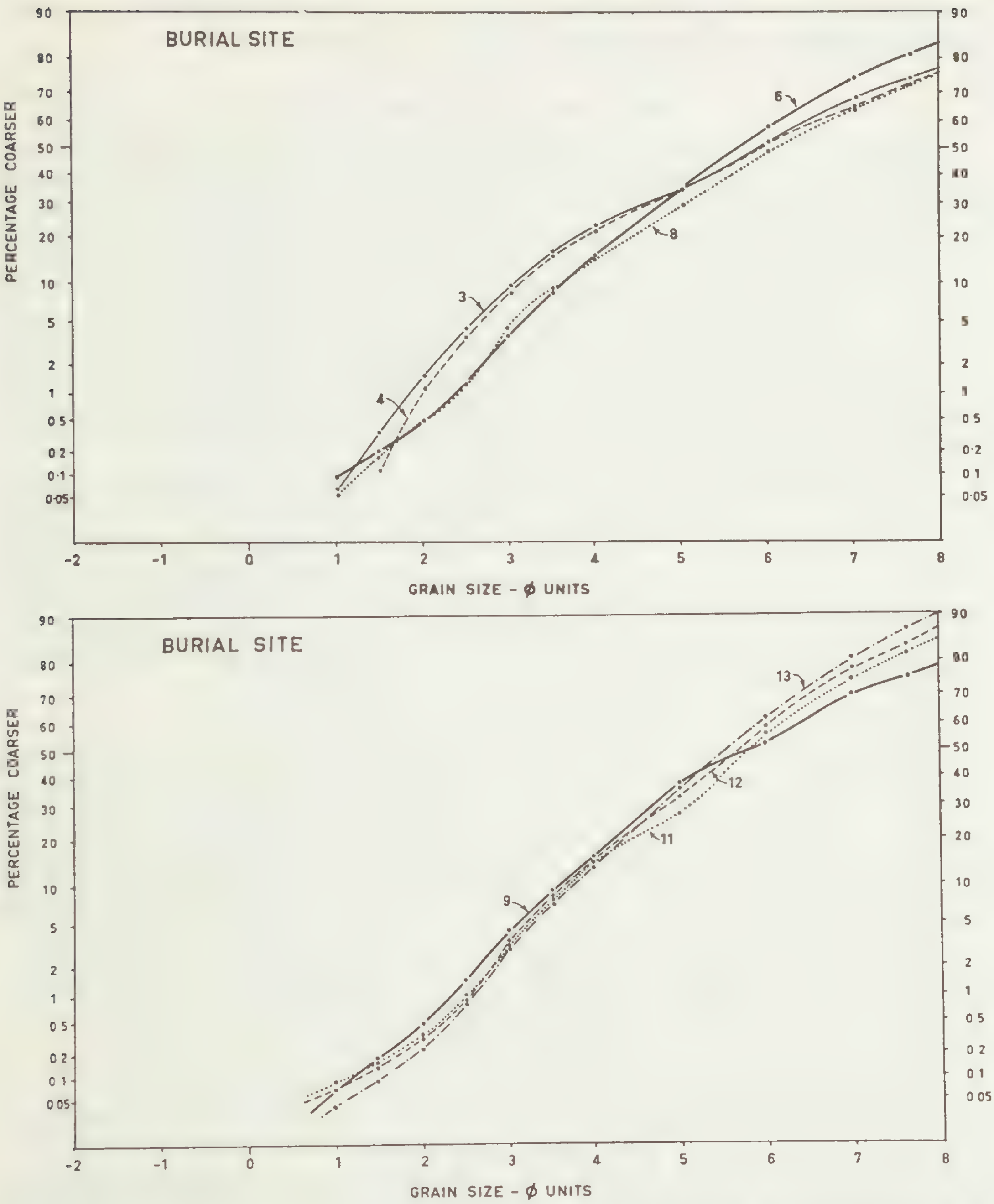


Fig. 15—Textural distribution curves of samples from burial excavation. Sample numbers as in Fig. 11.

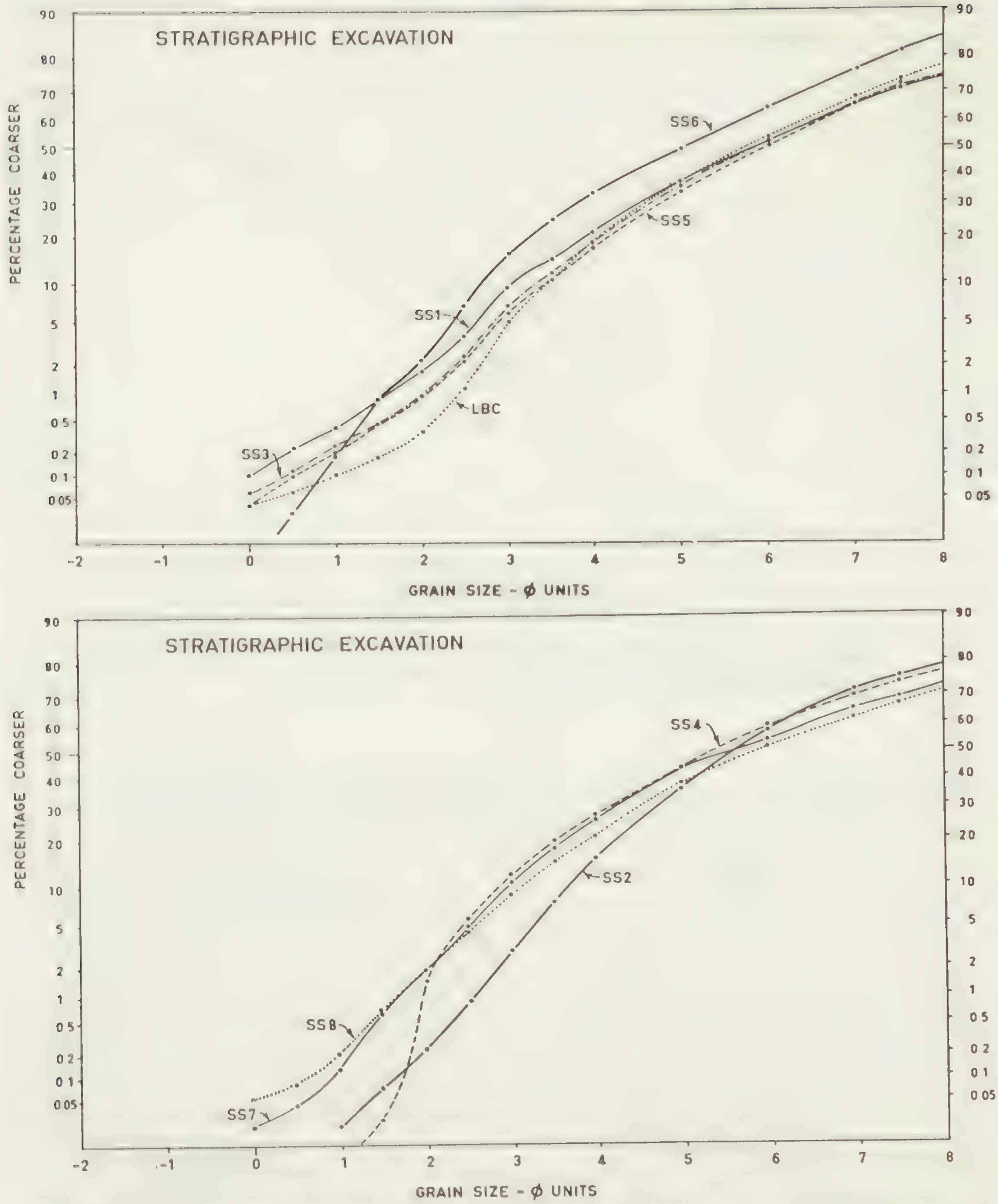


Fig. 14—Textural distribution curves of samples through stratigraphic excavation. Sample numbers as in Fig. 7.

bonate in figures accurately represents the upper and lower limits of its occurrence but should not be used as quantitatively defining its abundance.

Stratigraphy of the Burial Zone

The burial was located in a particularly complex part of the terrace. Reconstruction of the undisturbed topography placed the burial close to the contact between the two main terrace bodies. To determine adequately the age of the burial, it was necessary to establish its relationship in space and time with the soil-sedimentary zones already recognized near the terrace contact. An additional complication lay in the possibility of a stratigraphic discontinuity within the upper 3-4 ft of the Keilor terrace in this region. The presence of an erosional break, accumulation of the intermediate zone and a period of weak pedogenesis, had already been shown to predate deposition of terrace GGJ. The extensive evidence of fires localized within the intermediate zone, and the close proximity of the burial to one such zone of burning, pointed to a close relationship in time between the burial, the intermediate zone, and the period of non-deposition.

In the relationships between the three sedimentary units recognized near the terrace contacts, two possibilities were envisaged as shown in Fig. 16. In the first case, sediments of GGJ are inset into a zone eroded into the Keilor terrace (inset theory). In the second case (Fig. 16B), sediment of GGJ is inset and also overtopped onto the higher level depositing the upper 30 in. of the Keilor terrace (overbank theory). The consecutive lettering in the figures show the different orders of deposition implied in the two alternatives. Independent discriminating lines of evidence were therefore sought as outlined below.

Evidence from spatial relationships

The topography of the terrace contacts was accurately reconstructed using levels from the undisturbed surface 20 ft N. of the stratigraphic excavation. Information from this excavation and the burial site was then projected onto the topographic profile to represent the original spatial relationships as they existed in the undisturbed terrace. Thus the burial was located close to the topographic and sedimentary contact between the terraces, and both to the intermediate zone and to the disconformities which delimited it (Fig. 16). Unfortunately, the upward or W. continuation of bedding in the dipping sediment of GGJ (Fig. 7) merged a few feet W. of the stratigraphic excavation into soil where all trace of bedding was destroyed. Thus the lateral continuity of bedding could not be used to resolve the problem.

Evidence from textures and organic content

The information established in the stratigraphic excavation has been presented alongside that of core 7 (Table 2, Fig. 9). Discrimination between the overbank or inset theory depends on the presence or absence of the disconformity within the profile represented by that core. Two features in particular point to its presence. The first is the rise in organic content near 48 in. and above 36 in. consistent with the deep pedogenesis representing in part a buried soil profile. Secondly, the presence of a textural change in the upper 36 in. shown by the consistent increase in sands coarser than 0·20 mm relates this zone with that of GGJ sediment rather than with uninterrupted deposition during a single phase of Keilor terrace aggradation. Similar trends are apparent in the depth function of core 6 (Fig. 8). But the general significance of this evidence could only be confirmed by its consistency over larger areas and especially near the burial zone.

Textural analyses were therefore carried out on samples from the burial ex-

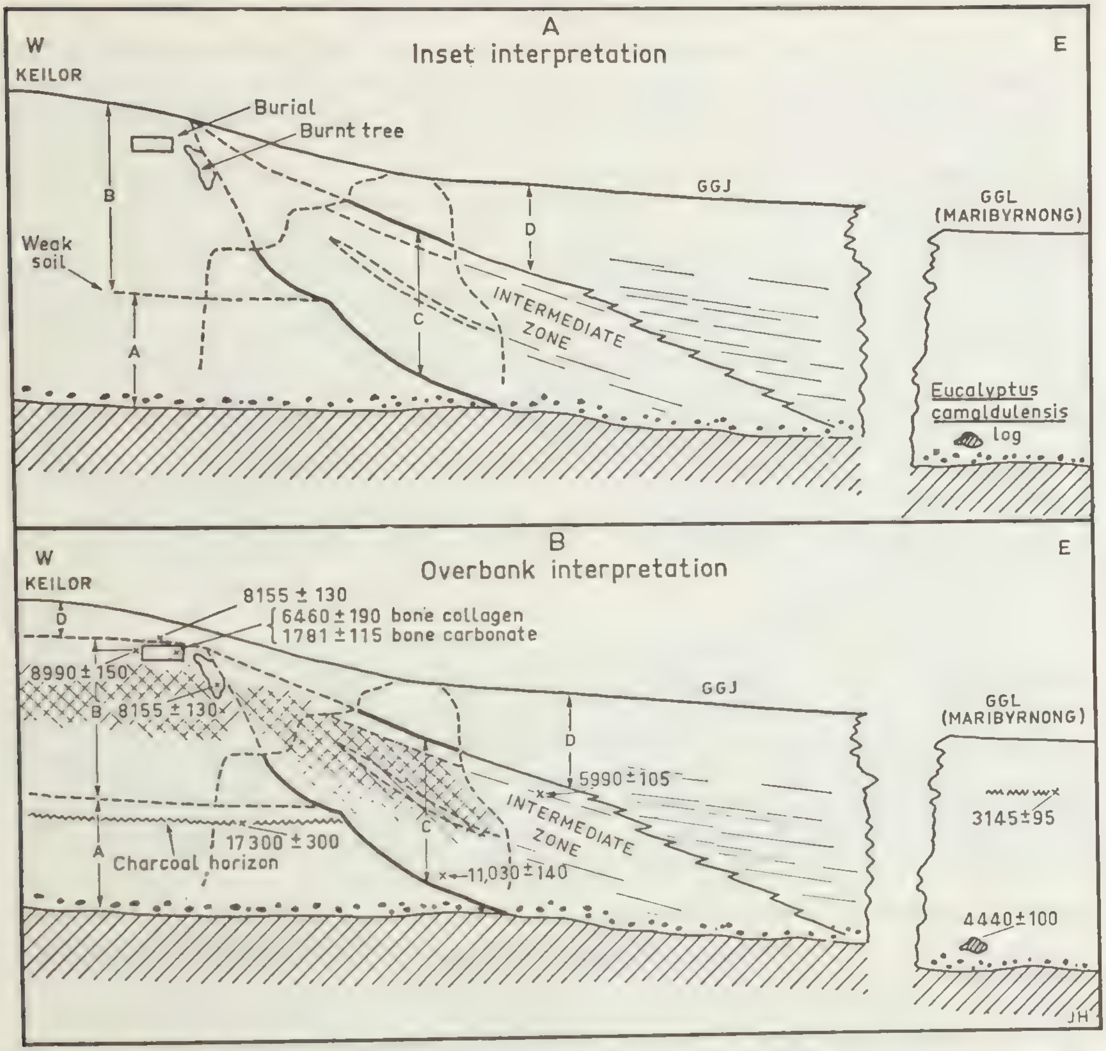


Fig. 16—W. to E. stratigraphic sections across terrace contacts to show alternative explanations possible to explain stratigraphy exposed in excavation, Fig. 7, the outlines of which are shown in dashed lines. The different sequences of deposition implied in these alternative hypotheses are illustrated by consecutive lettering of sedimentary units A to D from oldest to youngest. Radiocarbon dates from sequence are shown in their relative stratigraphic positions. The hachured area indicates occurrence of pedogenetic carbonate.

cavation site (Figs. 11 and 15). These show a markedly uniform textural distribution in sediment in and near the grave, but change significantly approximately 12 in. above the burial. This is best seen in the variation of sand coarser than 0·20 mm (Fig. 11). Samples below 30 in. (R.L. 59 ft) possess a uniform sand percentage coarser than 0·20 mm (near 1%), but at 24 and 18 inches in the profile, this rises to 2% and 3% respectively resembling the sediment of GGJ in the upper part of the stratigraphic excavation and in cores 10 and 11.

This regular pattern suggests a change in environment consistent with a pause in deposition near R.L. 59 ft followed by commencement of aggradation of terrace GGJ with overbank deposition burying the earlier sediments of the Keilor terrace.

Evidence from biotic casts

The large casts, which occur below R.L. 60 ft near the burial, were infilled by material derived from the surface which existed at the time of their formation. Analyses of the internal infillings should therefore relate to the horizon from which they were formed. Fig. 11 shows the results of textural analysis from one such infilling compared to sediment above and below R.L. 59 ft near the burial. The similarity of the infilling texture to that of sediment below R.L. 59 ft (cf. also the lower samples of cores 6 and 7, Figs. 8, 9, 12 and 13) supports the claim that the original burrows were formed before the deposition of the upper 3 ft of terrace sediment, probably during a phase of slow deposition or complete hiatus. It is significant that occasional casts occur in the intermediate zone (Fig. 7) but none have been found in either the top 30 in. of the Keilor terrace or in terrace GGJ. Moreover, had this burrowing and admixing of soil materials been operative after the deposition of the upper 30 in., the small textural changes evident at this level would have been removed by homogenization.

In addition, no evidence of such casts was found above the burial. The skeletal remains were therefore interred after the cessation of biotic activity, but before the next phase of aggradation which deposited the upper 30 in. and the lower terrace GGJ.

Evidence from soil carbonate

Secondary carbonate concentration is restricted to the Keilor terrace profile below 36 in. and to the intermediate zone, where both weak carbonate organization (filament and surface coatings) and reworked nodules were recorded. No additional carbonate deposition has occurred in the Maribyrnong Valley in sediments younger than the intermediate zone. The slight carbonate accumulation on the bones of the burial lowest in the grave (Macintosh 1967) was due to the burial being dug into a calcareous soil already in existence at that time. Carbonate organization therefore mainly predated the burial, as pointed out by Macintosh.

Evidence from burnt tree remains

The occurrence of thick concentrations of charcoal and oxidized silt corresponding to the burning of *in situ* trees and horizontal logs, described earlier, is similarly restricted to the Keilor terrace below the burial and to the intermediate zone. No large fire-burnt zones were recorded within either the upper 30 in. of the Keilor terrace and only one in sediments of GGJ. Redistributed pellets of pink oxidized silts to ¼ in. diameter occurred from 30 to 49 inches in the Keilor terrace and in the intermediate zone. But they too were absent from the top 30 in. of the Keilor terrace and sediments of GGJ, thus reinforcing the depositional relationship postulated between these two units. Two periods of burning were involved—one near the grave before carbonate deposition and a later period synchronous with deposition of the intermediate zone as described earlier.

In summary, the occurrence of carbonate, large biotic casts, and burnt tree remains, relate the intermediate zone to the lower part of the Keilor terrace soil profile. Moreover, the evidence from spatial relationships together with the textural trends and similarities between the top 30 in. of the Keilor terrace with sediment of GGJ, are all consistent with the theory of overbank deposition rather than the inset theory (Fig. 16). This hypothesis was advanced earlier (Bowler *et al.*, 1967) on the basis of the field and radiocarbon evidence then available. Since then, additional laboratory and radiocarbon evidence has reinforced this interpretation. The Keilor terrace soil at this locality is therefore a polygenetic profile with a paleosol overlain by 24-30 in. of sediment texturally and mineralogically little different from the underlying alluvium.

Chronology of the Burial Zone

Radiocarbon evidence

Radiocarbon dates obtained from the Green Gully region are set out in table 3, and their positions in the stratigraphic sequence are shown in Figs. 5, 16 and 18.

Of the two dates initially obtained (Bowler *et al.*, 1967) one was from charcoal in a root zone below the burial at R.L. 54 ft 5 in. (V-65) while the other (V-63) was from pellets of redistributed charcoal above the upper level of the burial at R.L. 59 ft 4 in. Both samples yielded C14 ages of 8155 ± 130 B.P. These provide an estimate of the age of the zone of burning into which the grave was dug rather than the age of the burial itself. The coincidence in the levels of C14 activity have been previously discussed (Bowler *et al.* 1967, Casey and Darragh *this volume*). The remaining charcoal sample from the equivalent level of the burial site (V-64) provides a better estimate of the age of the undisturbed sediment or upper terrace level at R.L. 58 ft 9 in. in which the remains were located. The latter have been dated independently at 6,460 ± 190 B.P. from analysis of bone collagen (Macintosh 1967).

Two additional samples from the intermediate zone (V-74 and V-75), indicate that the channel was already present before 11,000 B.P. and that the accumulation of the intermediate zone extended from 11,000 until after 6,000 B.P. This period corresponds to one of slow deposition and soil formation on the surface of the Keilor terrace with simultaneous erosion along the channel margin corresponding to accumulation or deposition of the intermediate zone. From the occurrence of reworked carbonate concretions and biotic casts or tubules, this episode continued until after pedogenesis had produced these features in the Keilor terrace soil. Pedogenesis was initiated near 11,000 B.P. under conditions of slow deposition, and continued until after 8,000 B.P. when fragments of reworked soil material began to find their way into the accumulating intermediate zone. When the burial occurred, again under stable conditions, the intermediate zone had developed a stable slope and was itself subject to pedogenesis simultaneously with continued carbonate mobilization on the higher Keilor terrace. This situation ended when aggradation recommenced soon after 5,000 B.P.

PART 3

Stratigraphy and Interpretation of the Terrace Sequence

In addition to the study of stratigraphic detail in the immediate vicinity of the burial zone, restricted to the upper levels of the Keilor terrace, data were collected from other terrace deposits and from lower levels of the Keilor terrace. Although not directly related to the burial, these data are included to provide a more adequate basis for understanding the stratigraphy and chronology of the entire sequence in the valley.

Arundel terrace and associated sediments

In the M.M.B.W. trench section on the right side of the river, a complex stratigraphic sequence was exposed (Fig. 19). Here some 15 ft of Keilor terrace silts were inset into eroded calcareous sandy clays of the Arundel terrace, a small remnant of which was preserved near R.L. 80 ft. Along the zone of contact between the Keilor and Arundel units, a zone of red calcareous clay marked the disconformity. This showed evidence of soil organization, in the segregation of carbonate into soft concretions, and in the development of prismatic or columnar structure with waxy clay cutans lining the prism surfaces. Approximately 3 ft below the surface of this zone, a layer of soft charcoal was traced for more than 20 ft following the general

TABLE 3

Radiocarbon dates from near Green Gully, Maribyrnong River

Lab. No.	Age Years BP	Description
Samples from Green Gully		
V-78	3,145 ± 95	Charcoal fragments from horizontal fire-burnt surface 8 ft beneath surface of Maribyrnong terrace in trench on left bank of Maribyrnong River near Green Gully. R.L. 36 ft. Collected J. M. Bowler.
V-77	4,440 ± 100	Fragment of red gum log (*Eucalyptus camaldulensis*) 22 ft below surface of Maribyrnong terrace in M.M.B.W. trench on left bank near Green Gully R.L. 22 ft. Coll. J.M.B.
V-75	5,990 ± 105	Charcoal from section exposed in Mahon's soil pit. Sample from near top of intermediate zone located 2 ft 6 in. beneath upper surface of soil buried by sediment of terrace GGJ. Coll. J.M.B.
V-63	8,155 ± 130	Redistributed charcoal fragments from few inches above top of burial. R.L. 59 ft 4 in. Coll. D. A. Casey and T. A. Darragh.
V-65	8,155 ± 130	Charcoal from zone of *in situ* burning of tree root 4 ft 9 in. below V-63 and approximately 3 ft below floor of grave. Root intruded from a surface near level of grave. R.L. 54 ft 5 ins. Coll. D.A.C. and T.A.D.
V-64	8,990-± 150	Charcoal fragments from approximately 4 in. below top of grave but outside burial area. Dates sediment into which burial dug. R.L. 58 ft 9 in. Coll. D.A.C. and T.A.D.
V-74	11,030 ± 140	Charcoal from root of tree growing at base of intermediate zone near unconformable contact with Keilor terrace sediment. Provides estimate of lower age limit of intermediate zone developed along channel edge. Coll. J.M.B. and R. J. Lampert.
V-79	14,940 ± 500	Charcoal associated with *in situ* fire, oxidized silts and bone fragments 15 in. above disconformity near base of section through Keilor terrace at weir, approximately 200 yd upstream from Green Gully. Coll. J.M.B.
V-73	17,300 ± 300	Charcoal fragments from extensive horizontal surface of pink oxidized silts from lower zone of stratigraphic excavation and floor of soil pit RL 42 ft 6 in. Coll. J.M.B.
V-76	30,700 ± 1,850	Charcoal distributed along bedding plane in colluvial red clays in M.M.B.W. trench. Clays were redeposited from higher Arundel terrace after erosion of that surface and were later buried during aggradation of Keilor terrace. Coll. J.M.B., D. J. Mulvaney and A. Bermingham.
Dates from carbonate and skeletal remains		
NZ-676	6,460 ± 190	From bone collagen, determined on fragments of Green Gully human remains (Macintosh 1967).
NZ-675	1,781 ± 115	From bone carbonate fraction of Green Gully remains represented by collagen date above (Macintosh 1967).
	7,360 ± 105	Carbonate from encrustation on original Keilor cranium. (E. D. Gill *pers. comm.*).
Additional dates		
GAK-996 GAK-985	7,700 ± 140 7,710 ± 150	From sections in Keilor terrace upstream from the soil pit at Green Gully. Stratigraphic relationship to sequence at Green Gully not available. (E. D. Gill *pers. comm.*).

E. slope of the deposit. The zone of red clay with pedogenetic features represented a sedimentary deposit developed by downward movement of calcareous Arundel clays along the slope developed by stream incision into the older terrace. In this respect, it was identical in origin with the intermediate zone in the soil pit as described earlier. The valley slope and colluvial deposit so formed, remained stable long enough to allow the pedogenetic features to develop *in situ* before burial by the later Keilor terrace deposits.

From the radiocarbon analysis of the charcoal horizon (V-76, 30,700 ± 1850 B.P.) the age of the incision into the Arundel terrace is placed at approximately 32,000 B.P. while the accumulation of clay and soil formation occupied the period from approximately 31,000 until the deposition of the Keilor terrace silts at approximately 18,000 B.P. This situation is similar to that reported from the excavations of A. Gallus at the cranium site (Polach *et al.* 1968). The independent radiocarbon data from both sites confirm the validity of the chronological sequence outlined above.

Keilor terrace

Data from the lower levels of the Keilor terrace are available from the soil pit and from a section on the right bank of the river near the weir approximately 200 yards upstream. Charcoal from the extensive horizontal zone of burning exposed near R.L. 42 ft in the stratigraphic excavation (Fig. 7) has provided a radiocarbon age of 17,300 ± 300 B.P. (V-73). This was located only 1 ft 6 in. below the soil disconformity suggesting an age for that surface of approximately 16,500 B.P. Confirmatory evidence is available from the weir section where charcoal distributed on a horizontal surface with burnt bone fragments at R.L. 49 ft, only 1 foot above a break in deposition, yielded an age of 14,940 ± 500 B.P. (V-79). On the basis of the similarity in levels, pedogenetic features and radiocarbon ages, the sedimentary break and weak soil developed at this level can be reliably correlated between sites (Fig. 20). Moveover, the duration of the depositional break would appear to extend

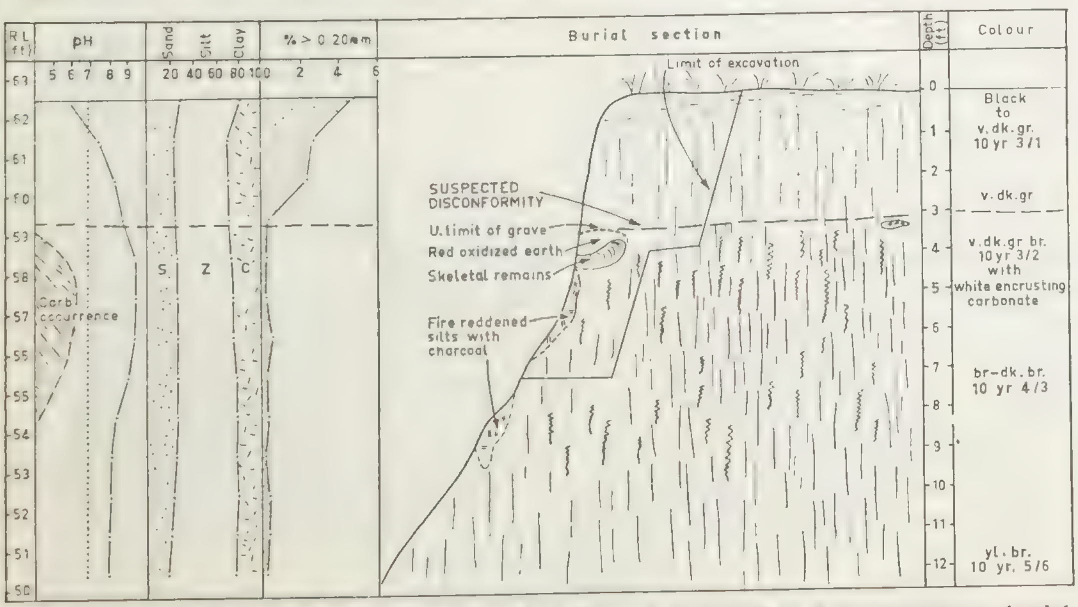


Fig. 17—Section summarizing depth function data through top 12 ft of Keilor terrace at burial site. The deeply organized chernozemic soil is thought to be a polygenetic profile with a disconformity near top of burial zone. The zone below burial contains carbonate and many biotic casts or tubules which are absent in top 30 in. of terrace.

from approximately 16,500 to 15,000 B.P. Depositional details of the higher and younger horizons in the Keilor terrace have been discussed earlier.

Maribyrnong terrace

In the M.M.B.W. trench on the left side of the river, approximately 20 ft of vertical section was available for examination. This consisted of homogeneous sandy silts with a close textural resemblance to those of the Keilor terrace although slightly darker in colour reflecting higher organic content. No bedding traces were preserved. Samples from two levels selected for radiocarbon analysis provided ages of 4,440 ± 100 (V-77) and 3,145 ± 95 (V-78) as outlined in Table 3 and Fig. 16.

Correlation of terrace GGJ

In the sequence described here, the Keilor and Maribyrnong terraces are separated by the terrace GGJ. Although it has not been possible to trace this terrace through the valley, it would appear from its level and stratigraphic position to correlate with the Braybrook terrace of Keble and Macpherson. But as shown earlier, this terrace consists of a body of alluvium separated from the Keilor terrace by an erosional disconformity and a period of soil formation. It must therefore be considered as a separate body of sediment independent from the Keilor terrace and not formed by shallow surface erosion of the latter as postulated for the Braybrook terrace (Gill 1953), with which it seems to be identical at Green Gully. But in terms of its age, it is probably synchronous with the lower part of the Maribyrnong terrace.

Correlation with Keilor cranium site

The stratigraphy of the original cranium site near Dry Creek has been discussed by Keble and Macpherson (1946) and by E. D. Gill in a series of papers (see bibliography p. 57), although no definitive account of the stratigraphy and sediments of the Dry Creek locality is yet available. The chronology of the terrace as known in September 1965 is set out in Table 4.

Gill (1953) showed a section at the skull site with a prominent diastem located 9 ft below the terrace surface. The evidence for the diastem lay firstly, in the tendency for sediment to break away neatly along a horizontal surface producing a notch in vertical section, and secondly, the presence of a zone affected by pedogenesis immediately beneath this level. Below the diastem Gill (1966) recognized a weak duplex soil profile with carbonate and clay accumulation in the buried B horizon. Since the cranium was encrusted with secondary carbonate, this provided evidence of its original position within the terrace which has been estimated at 18 ± 6 in. below the diastem (Gill *op. cit.*). From the evidence available, a reconstructed section of the skull site is shown in Fig. 18 with the radiocarbon chronology as deduced by Gill. In any attempt to compare this with the Green Gully site, the chronology presents some difficulties.

Firstly, the only date above the diastem (W-169) was collected 5 miles downstream from Dry Creek at Braybrook (Fig. 1). Its correlation with the cranium site rests on:

1. Its position 2 ft 6 in. above a diastem at Braybrook, and
2. the lateral continuity of that diastem along the valley between Braybrook and Dry Creek.

If the extrapolation from Braybrook to Dry Creek is accepted, the diastem at the latter locality would fall within the range 15,000 to 8,500 B.P. as postulated by Gill (1966 p. 584).

This chronology cannot readily be correlated with the evidence from Green

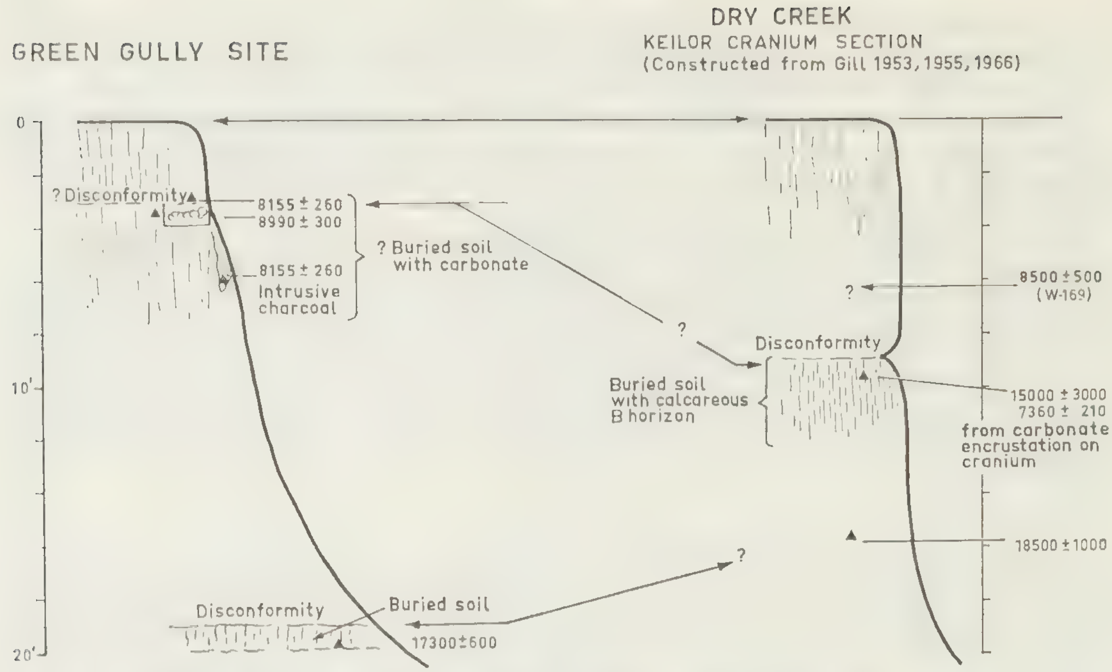


Fig. 18—Diagram showing correlation between composite sections at Green Gully and Keilor cranium site. Radiocarbon sample W-169 collected at Braybrook is shown in position assigned to it by Gill on basis of its promixity to a disconformity at Braybrook which Gill has correlated with that at Dry Creek. Dates are reported with errors of *two standard deviations* to emphasize the relative degrees of uncertainty in chronology at these sites.

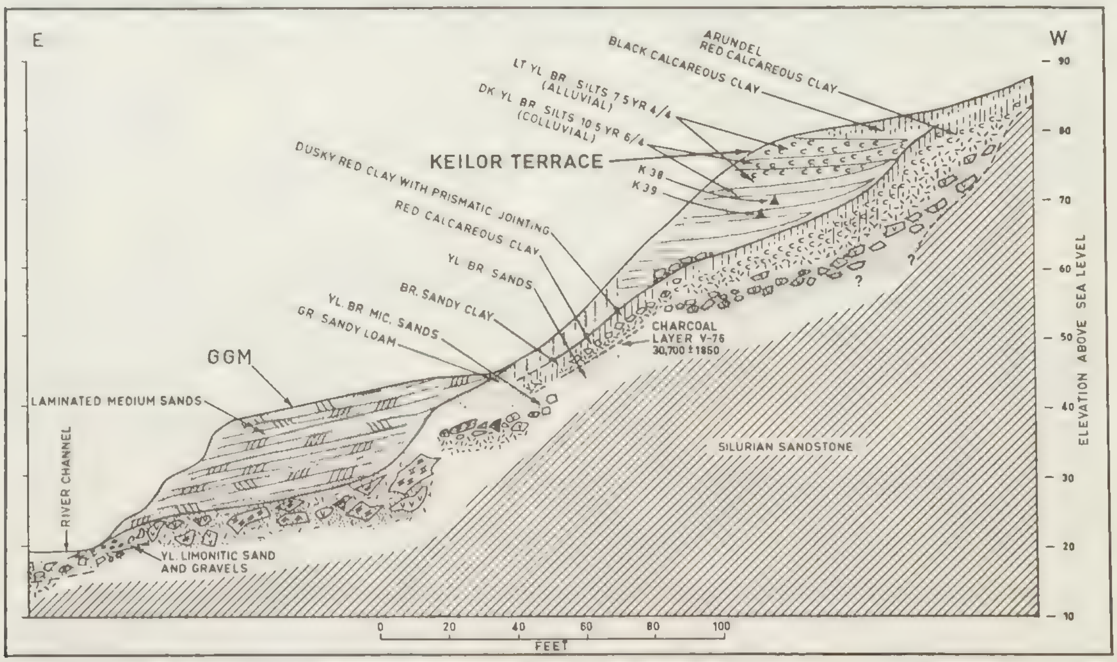


Fig. 19—E-W section through part of MMBW pipeline trench showing silts of Keilor terrace inset into eroded remnant of Arundel terrace. Colluvial silts within the Keilor terrace interfinger with alluvium which was deposited here to near R.L. 78 ft with a low initial dip to E. off valley wall. For line of section see Fig. 2.

TABLE 4

Additional radiocarbon dates from the Maribyrnong Valley

Lab. No.	Age Years BP	References	Comments
GX-O148	1,020 ± 80	Gill 1966	From log of *Eucalyptus* with its upper edge two feet from the surface of Maribyrnong terrace in soil pit on E side of Milleara Rd, Braybrook.
W-125	3,010 ± 160 or 3,100 ± 160	Rubin and Suess 1955 Gill 1955a, p. 50	From Keilor terrace four chains downstream from Medway Golf Links, Braybrook. Date regarded as too young on geological evidence because from a number of hearths in the terrace some deep, and others near the surface (Gill 1955a, p. 49). Rubin and Suess suggest some charcoal may be intrusive.
W-169	8,500 ± 250	Rubin and Suess 1955 Gill 1955a, 1955b	Charcoal from hearth from middle (vertically) of Keilor terrace at the E. end of moulding sand quarry on S. bank of river near Braybrook. Sample was 'from a mass of charcoal and reddened silt' 2 ft 6 in. above the diastem (Gill 1955b). Note the resemblance to features described in this report from near burial.
NZ-366	15,000 ± 1,500	Grant-Taylor and Rafter 1962 Gill 1966	Charcoal from carbonaceous lens below diastem at Keilor cranium site 6 ft 9 in. above NZ-207. Grant-Taylor and Rafter report 'sample was too small to separate carbon and carbonate and the age is therefore an order of magnitude only.'
NZ-207	18,000 ± 500	Grant-Taylor and Rafter 1962	Charcoal from hearth at site of Keilor cranium 5 ft 9 in. below level of cranium i.e. 6 ft 9 in. below the level of the diastem (Gill 1961). This is equivalent to 16 ft. below the surface of terrace from figure 1 of Gill 1953.
All the above samples were collected by E. D. Gill			
ANU-65	31,600 + 1,100 − 1,300	Polach *et al.* 1968	Charcoal from red (reworked Arundel) clay beneath the basal Keilor terrace sediments at Dry Creek cranium site. Coll. A. Gallus.
ANU-81	24,000 + 3,300 − 5,700	Polach *et al.* 1968	Charcoal from same sedimentary unit as ANU-65 buried beneath Keilor terrace sediments. Coll. A. Gallus.

Gully where the main pause in deposition commenced near 11,000 and continued until near 5,000 B.P. While the disconformity at Green Gully has some features in common with that reported from the cranium site, the lateral continuity of the latter and its synchronous development throughout the valley have still to be verified. Therefore its use as a datum to extrapolate radiocarbon data from Braybrook to Dry Creek remains open to question.

The age of main soil profile development at Green Gully determined from the limiting ages of carbonate accumulation can be reliably estimated as lying between 11,000 and 5,000 B.P. A radiocarbon date obtained from carbonate encrustation on the original Keilor cranium of 7,360 ± 305 (Gill *pers. comm.*) is in agreement

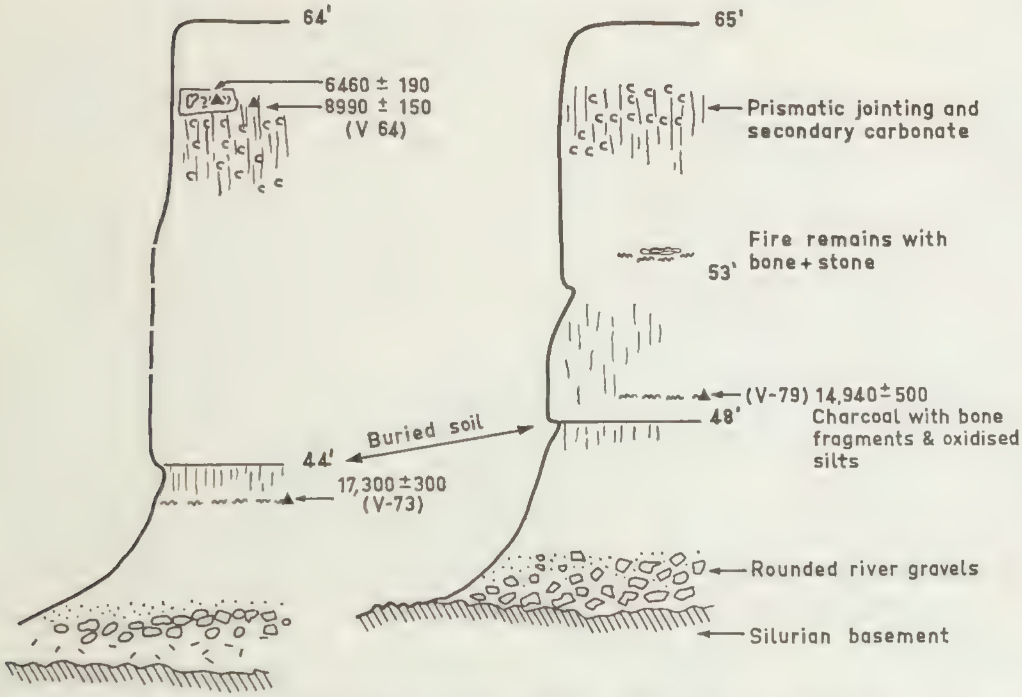


Fig. 20—Sections showing correlation between Green Gully soil pit and weir site. The stratigraphic break with weak soil development is bracketed by radiocarbon dates (V-73 and V-79) which place age of soil formation at approximately 16,500 to 15,000 B.P.

with this estimate, although radiocarbon age determinations on secondary carbonates tend to yield values younger than the true age of carbonate accumulation. This age however, is consistent with carbon mobilization and accumulation near 9,000 B.P. at both sites.

Secondly, the true age represented by sample NZ-366 (15,000 ± 1,500) could fall anywhere in the range of 12,000 to 18,000 B.P. But since sediment 6 ft 9 in. below has yielded an age of 18,000 ± 500 B.P. (NZ-207), the true age of NZ-366 is not likely to be older than 15,000 while it could be considerably younger.

In view of the doubts attached to the extrapolation of the Braybrook sample, the disconformity at Dry Creek may be younger than the age assigned to it by Gill (1966), and may be related instead to the disconformity at Green Gully. Correlation between sites on this basis, assuming synchronous pedogenesis in the Keilor paleosol (carbonate organization, organic activity, etc.) remains tentative; furthermore, it requires different rates of deposition at each site as in Fig. 18. The difficulties in such a correlation perhaps may be resolved by additional stratigraphic and radiocarbon data, especially from the cranium site.

Terrace Formation and Environmental History

Causes of terracing

Of the three major processes commonly invoked in terrace formation (tectonic, eustatic and climatic processes) all have played some part in the evolution of the Port Phillip sunkland in which the Maribyrnong River terraces are located (Hills 1960, Bowler 1966). Keble and Macpherson (1946) advanced evidence of minor tectonic deformation affecting the Maribyrnong River downstream from Keilor. These comprised the 'Footscray and Keilor warps', but as they conceded (p. 67),

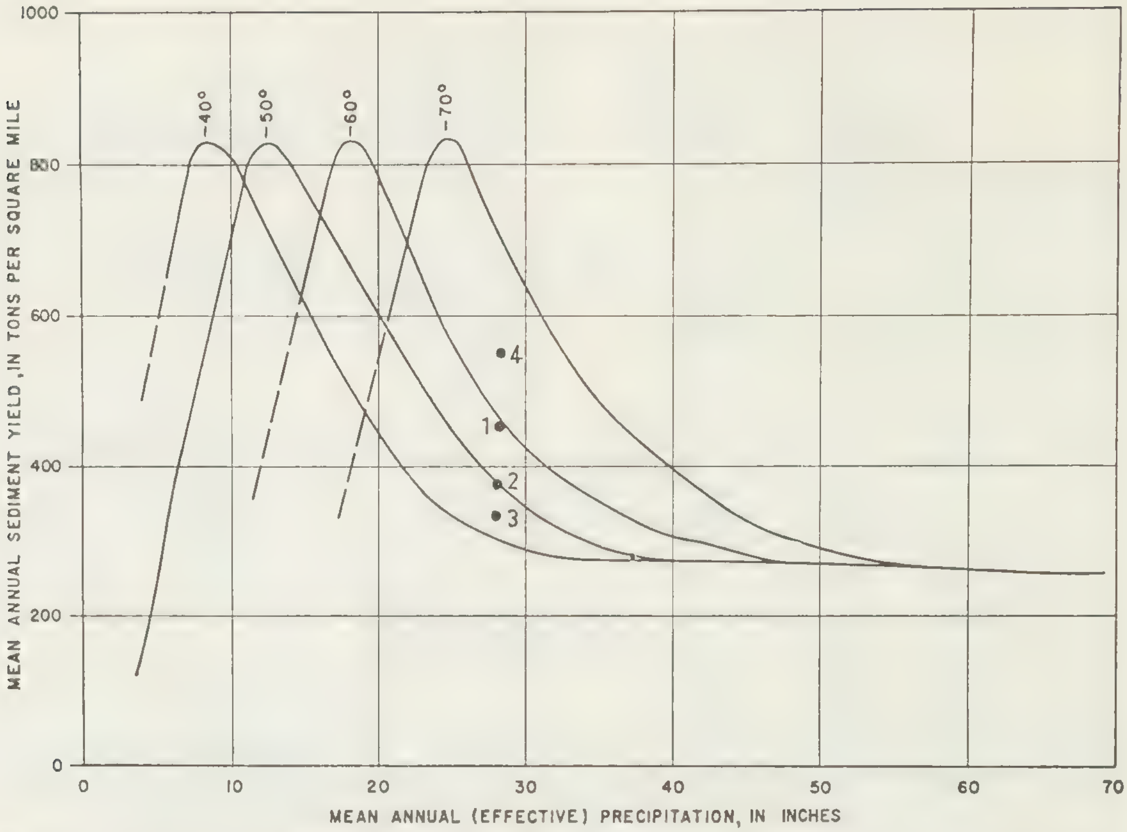


Fig. 21—Curves showing the relationship of sediment yield to variations in mean annual rainfall for a range of mean annual temperatures from 40° to 70° (from Schumm 1965). Point 1 is equivalent to present environment of Maribyrnong River catchment upstream from Keilor. Points 2 and 3 show estimated position during cold glacial conditions with mean temperature lowering conservatively and maximally estimated at 9° and 15°F respectively lower than present mean annual temperatures. Point 4 shows estimated position during interglacial time with mean temperatures conservatively estimated at 5°F higher than present.

they produced little significant effects on the river profile. Gill (1961) has questioned the presence of these structures. More important movements have occurred during Quaternary time on the major tectonic lineaments controlling the sunkland, i.e. on the Rowsley Fault on the W. and on Selwyn's Fault on the E. Movements post-dating the Newer Basalt flows have affected the profiles of the Barwon, Moorabool and Werribee Rivers in the W., causing deep incision and formation of terraces upstream from the faults on which movement occurred. But the Maribyrnong River has not been so affected, as it does not cross a major structure.

Some tilting of the sunkland block by differential movement on marginal structures cannot be ruled out, although the effects are difficult to evaluate. It is indeed probable that some such tilting has occurred, but its effects on stream profiles are not known. There is neither specific evidence to associate terracing in the Maribyrnong River with tectonic movement—nor is there sufficient evidence to rule out totally a small tectonic influence.

Keble and Macpherson proposed a eustatic origin for the terraces which they associated with the Würm glacio-eustatic oscillations. The Keilor terrace was deposited synchronously with rising sea level in the glacial to late glacial period from 18,000 to about 8,000 B.P., but the eustatic rise need not have caused the aggrada-

tion as Gill (1953, 1957) has pointed out. The long profile of that terrace passes from R.L. 64 ft near Green Gully to beneath sea level some 10 miles downstream near Maribyrnong (Gill 1961). The gradient of the terrace surface is in excess of that of the river bed, which is hard to reconcile with eustatically controlled aggradation. Moreover, aggradation was active at least 15,000 B.P. when sea level was perhaps 200 ft lower than present and when the shore line was located further out into Bass Strait. Any direct cause and effect relationship between aggradation at Keilor and sea level oscillations in Bass Strait is an unlikely proposition, although both occurred simultaneously.

As argued by Gill (1953, 1954), the most likely cause of terrace formation is climatic change. The textural evidence from the Keilor terrace is consistent with all but the basal 4-5 ft being deposited from suspended load. The top 30 in. of the terrace, as established earlier, has been deposited by overbank deposition, synchronous with the existence of the channel eroded into the Keilor terrace proper. Texturally this top 30 in. is so similar to the remainder of the terrace sediment that a similar overbank depositional regime may be invoked to account for the entire thickness of the fine sands and silts comprising the top 23 ft of this terrace.

But attempts to extrapolate from river terrace stratigraphy to climatic reconstruction encounter many difficulties. Flint (1957) has pointed to the tendency to ignore the many complex variables involved in the response of any drainage system to a particular change in the climatic regime. A single shift in climate may produce different effects in neighbouring basins or in different parts of the same basin. Nevertheless, many Quaternary workers have relied heavily on fluviatile evidence to support their climatic hypotheses, sometimes drawing opposite conclusions from the same evidence (cf. the controversy over Nile terrace sediments: Butzer 1964, p. 304; Fairbridge 1963, p. 308; or the disputed climatic control of prior streams on the Riverine Plain: Butler 1960, Langford-Smith 1959). The Maribyrnong river terraces have also been used as evidence in favour of high rainfall or pluvial conditions during late Pleistocene time. Gill (1954, p. 111) states 'Keilor time was one of much heavier rainfall . . .' and again (1956) 'the rainfall was greater in Keilor times because from the same valley floor the waters of the river built a much higher floodplain'. This conclusion may be in part correct but it does not necessarily follow from the evidence cited. The use of floodplain or terrace levels to reconstruct discharge presents many difficulties as the following calculations will show.

The best example of high floodplain deposition is found in the M.M.B.W. section on the right side of the river S. of the soil pit. Here interdigitating layers of different colour and texture within the Keilor terrace, dip conformably to the E. off the steep W. slope (Fig. 19). These represent alternate layers of alluvial and colluvial deposition; the former are texturally identical with the silts of the Keilor terrace and thicken towards the floodplain to the E., while the latter show poor sorting with a high percentage of medium to coarse sand and thicken upslope to the W.

Alluvial deposits have been identified here higher than R.L. 76 ft requiring flooding in excess of this level for their deposition. Assuming a channel was present with its bed near the base of the terrace, this would involve a minimum flood height of 34-36 ft above the channel floor, corresponding to a depth of approximately 13 ft over the upper level of the floodplain (R.L. 63 ft).

The highest recorded discharge in the Maribyrnong River occurred during the flood of 1916 when the river reached a height of 36 ft on the gauge 1 mile upstream from the soil pit, corresponding to a discharge of 17,000 cusecs (State Rivers and Water Supply Commission 1964). Assuming the same flood-height in the soil pit area, it is possible to compare the cross-sectional area involved in the flow of the 1916 flood with the reconstructed cross-sectional area of the flooding required to

deposit the highest sediments of the Keilor terrace. In Table 5 the surface of the terrace is presumed to have aggraded to near 63 ft across the valley sloping up to near 76 ft where alluvium has been identified. The presence of a channel of approximately the same dimensions as the present river channel is assumed (2400 sq ft). On the basis of this reconstruction, the cross-sectional area of a flood reaching to R.L. 76 ft in Keilor terrace time can be calculated.

TABLE 5

Comparison of discharges necessary to deposit upper part of Keilor terrace with those of largest recorded flood in Maribyrnong River

	Area A	Gradient S	Discharge Q	Velocity V
1916 flood assuming flood height at Green Gully of 36 ft. above channel floor as recorded on gauge 1 mile upstream	8,970	0·0010	17,000 (measured)	1·895
Reconstructed figures for deposition of Keilor terrace to R.L. 76 ft assuming average floodplain level near 63 ft and maximum channel aggradation to 43 ft	10,540 (A_k)	0·0014	23,600 Q_k	V_k

A = cross-sectional area of flow across the valley in square feet.
S = average downstream gradient of floodplain surface from near Keilor to a point 12 miles downstream.
Q = discharge in cusecs.
V = average velocity across floodplain (ft/sec.) calculated from relationship Q = A × V

From Manning's equation, $V \alpha S^{\frac{1}{2}}$ when depth and roughness factors are constant. In the case in question, the depth of reconstructed flow across the floodplain surface is approximately 13 ft in both cases and both surfaces would present similar resistance to shear.

$$\text{Thus } V^2 = KS \text{ where } K \text{ is constant}$$

Substituting the values for the 1916 flood conditions from Table 5

$$K = 3591$$

Using this value of K, the velocity of flow across the Keilor floodplain surface can be determined.

$$V_k = (3591 \times 0{\cdot}0014)^{\frac{1}{2}}$$

$$\text{But } Q_k = V_k \times A_k$$

Substituting values for V_k and A_k

$$Q_k = 23{,}600 \text{ cusecs.}$$

Note that even if no adjustment is made for the differences in the gradients of the floodplain surfaces, then on the basis of cross-sectional area alone, the discharge required to deposit the highest Keilor terrace sediments would exceed that of the 1916 flood provided a channel was present. But in drainage basins subject to ephemeral flow in S.E. Australia, channels are sometimes absent. After high intensity rain, water flows across grass-covered alluvium depositing a layer of silt and clay. It is possible under conditions of reduced flow during an arid period, that even large channels such as that of the Maribyrnong River may have been infilled. Ephemeral flow, lacking coarse bedload sediment, would then be limited to the floodplain rather than to a channel regime. Assuming that such conditions were possible, and if no channel was present during the deposition of the high level alluvium, the depositing discharges would be reduced from 23,600 to 18,200 cusecs, close to that of the present maximum recorded discharge of 1916.

Two interpretations can therefore be placed on this type of evidence. In the first,

assuming the presence of a channel, deposition is associated with flow stages higher than any recorded under the present regime. In the second, the processes responsible are ephemeral stream activity or sheet flow across an alluviated valley floor after high intensity rains. This type of evidence may therefore be called upon to support both an arid climatic hypothesis as well as the pluvial conditions discussed above. In the writer's opinion, a channel was probably present during deposition of the upper terrace levels. But in the absence of confirmatory evidence for the existence of a channel at that time, the climatic reconstruction remains tentative. Moreover, it says nothing of the mean annual flow through the system and the climate which controlled it, for which additional evidence must be sought.

In recent years many studies have highlighted the complexity of drainage basin analysis and its relationship to hydrological regimes. Taking these variables into account, attempts have been made to determine in a semi-quantitative way the relationships between drainage basin morphology, river behaviour and climatic change (Chorley 1957, Dury 1965). The type of analysis most likely to assist in the interpretation of alternating phases of fluviatile erosion and deposition described here is that drawn from a study of modern stream behaviour over a wide range of climatic and hydrologic conditions. Such an attempt has been made by Schumm (1965) using data from modern streams representing a wide range of conditions. The complexity of changes induced by a single shift in climate, as it affects different drainage basins or different parts of the same basin, are demonstrated by Schumm (Table 2, p. 790). However, as Schumm points out, in the absence of additional field data, this type of analysis can only point in the general direction of change and provide orders of magnitude rather than quantitative answers. Nevertheless, it provides the best means presently available for objectively interpreting an alternating sequence of erosion and deposition. This study will therefore conclude with an analysis of the evidence from the Maribyrnong River terraces in terms of the hydrologic and climatic relationships proposed by Schumm.

Hydrologic and climatic environment

The cyclic sequence of deposition, erosion, and soil formation demonstrated above, has been interpreted as due to changes of considerable magnitude in the climatic system controlling the fluviatile regime. The radiocarbon data and evidence of soil development indicate variable rates of deposition within the Keilor terrace, and therefore variations in the rates of sediment supply during the formation of that deposit. Sedimentation rates of 1·1 ft/1,000 yr. existed between the deposition of the radiocarbon samples V-73 and V-79 from the lower part of the terrace, compared with 2·1 ft/1,000 yr. between the equivalent levels represented by V-64 and V-79. If the evidence from the upper soil development, which had already begun before deposition of V-64, is further taken into account, the sedimentation rate for the central body of Keilor terrace alluvium (from R.L. 44 to R.L. 54 ft in the soil pit) must have been considerably in excess of 2·1 ft/1,000 yr.

From 11,000 to 6,000 B.P., depositional rates on the Keilor floodplain were reduced to less than 1 ft/1000 yr. Rapid aggradation recommenced at approximately 4,500 B.P. with the deposition of sediment of GGJ, equivalent to the basal Maribyrnong alluvium and to the alluvial cover on the upper level of the Keilor terrace. Estimates from radiocarbon samples V-77 and V-78 (Table 3) would suggest the high rate of vertical aggradation of 10 ft/1,000 yr. during this period.

These rates, in so far as they reflect variations in sediment yield or sediment concentration, can be used to relate the alluvial depositional phases to the hydrological data of Schumm (1965) and Langbein *et al.* (1949). Fig. 21 shows the position of Maribyrnong River data on the curves relating rainfall, sediment yield and mean annual temperature. A large change in both sediment yield and percentage

run-off can be brought about by a temperature change alone without any necessary change in absolute precipitation (Schumm 1965, Langbein *et al.* 1949). The effects of such temperature change are represented by the family of curves for different mean annual temperatures in Fig. 21. Assuming that precipitation remained constant, a small drop in temperature would have a similar effect on sediment yield as an increase in precipitation, i.e., sediment yield would decrease. Higher yields would accompany a decrease in mean annual precipitation or an increase in temperature, both of which would have a similar effect on run-off.

Thus if aggradation results from high sediment yields, then to produce these conditions in the Maribyrnong basin would require a shift from the present towards more arid conditions either in terms of lower rainfall or higher temperatures. Conversely, erosion of the floodplain corresponding to low sediment yield would accompany an increase in rainfall or decrease in temperatures, either of which would result in increased discharges.

While it is seldom, if ever, valid to infer precipitation changes from terrace evidence alone, independent evidence exists for world-wide temperature lowering during the last glacial maximum from approximately 30,000 to some time after 20,000 B.P. Estimates from the N. Hemisphere range from as low as 3°C from evidence near Lake Nevada (Antevs 1952) to more than 8°C (Schnell 1961, Schwarzbach 1961, Charlesworth 1957). From evidence in SE. Australia, Galloway (1965) has postulated a fall in temperatures of 9°C (16°F). Estimates vary according to the type of data used and the site from which they are drawn, but most favour a world wide lowering for which 5°C (9°F) is a conservative estimate. Temperature changes during interglacials may similarly be estimated as being approximately 5°F higher than at present.

In Table 6 estimates of run-off, discharge and sediment yield for glacial and interglacial conditions have been made using the relationships of Schumm (1956) and Langbein *et al* (1949). Additional data (Fournier 1960, Douglas 1967) suggest the need to modify the Schumm-Langbein curves in the region of high rainfall. But within the precipitation range relevant to the Maribyrnong Valley, there is no reason at present to doubt the general validity of the curves. For the purposes of the calculations, precipitation is assumed to have remained constant. In this way, the direction of changes and the order of magnitude may be estimated provided precipitation changes remained small, a reasonable assumption in view of the general lack of evidence in S. Australia for widespread increases in rainfall during glacial time (Galloway 1965).

From these calculations, glacial discharges two to three times higher than

TABLE 6

Hydrologic data from present regime of Maribyrnong River compared to postulated glacial and interglacial conditions, assuming no changes in precipitation

	Present regime	Glacial regime		Interglacial 5°F above present
		9°F below present	15°F below present	
Precipitation (ins.)	28	28	28	28
Mean annual temp. (F°)	59	50	44	64
Pan evaporation (ins.)	40	23	15	53
Run-off (ins.)	3·3*	7·0	10·0	2·0
Mean annual discharge (acre ft × 1,000)	86·6	172	262	52
Sediment yield (tons/sq. mile)	460	380	340	560

* From State Rivers and Water Supply Commission

TABLE 7

Correlation of terrace chronology, sediments and soil with a tentative sequence of climatic fluctuations

Terrace Sequence	Radiocarbon Age Years B.P.	Geological-Hydrological Sequence	Soil Development	Climatic interpretation (following relationships proposed by Schumm, 1965)
GGM		Erosion active with occasional floodplain deposition. Point bars from lateral stream migration	Weak soil formation *black alluvial soil*	
MARIBYRNONG GGL	2,000	Rapid deposition of Maribyrnong terrace		Low run-off produced by high temps. or low rainfall
GGJ	4,500	High sediment yields ? Low discharge		
upper / Intermediate Zone	6,000 8,000	Erosion of Keilor terrace, chanel incision, low sed. yield, occasional floodplain deposition during high stage flow ? High discharge	Main period of soil formation on Keilor terrace sediment with biotic activity and carbonate mobilization producing *chernozemic profile*	High run-off produced by high rainfall or low temperatures
KEILOR middle	12,000	Rapid deposition of middle zone Keilor terrace from suspended load regime, high sediment yield Low discharge		Low run-off produced by high temperatures or low rainfall
	15,000	Non deposition Transition	Weak soil on basal Keilor	Increasing temperatures
basal	17,000 20,000	Deposition of basal Keilor terrace simultaneously with erosion and destruction of Arundel floodplain by lateral stream migration. Shallow channel, bed-load regime High discharge	Soil formation on Arundel terrace sediment producing *red-brown earth profile*	Low temperatures, low evaporation producing high run-off.
ARUNDEL	31,000	Sediment of Arundel terrace deposited ? Low discharge		- Low run-off.

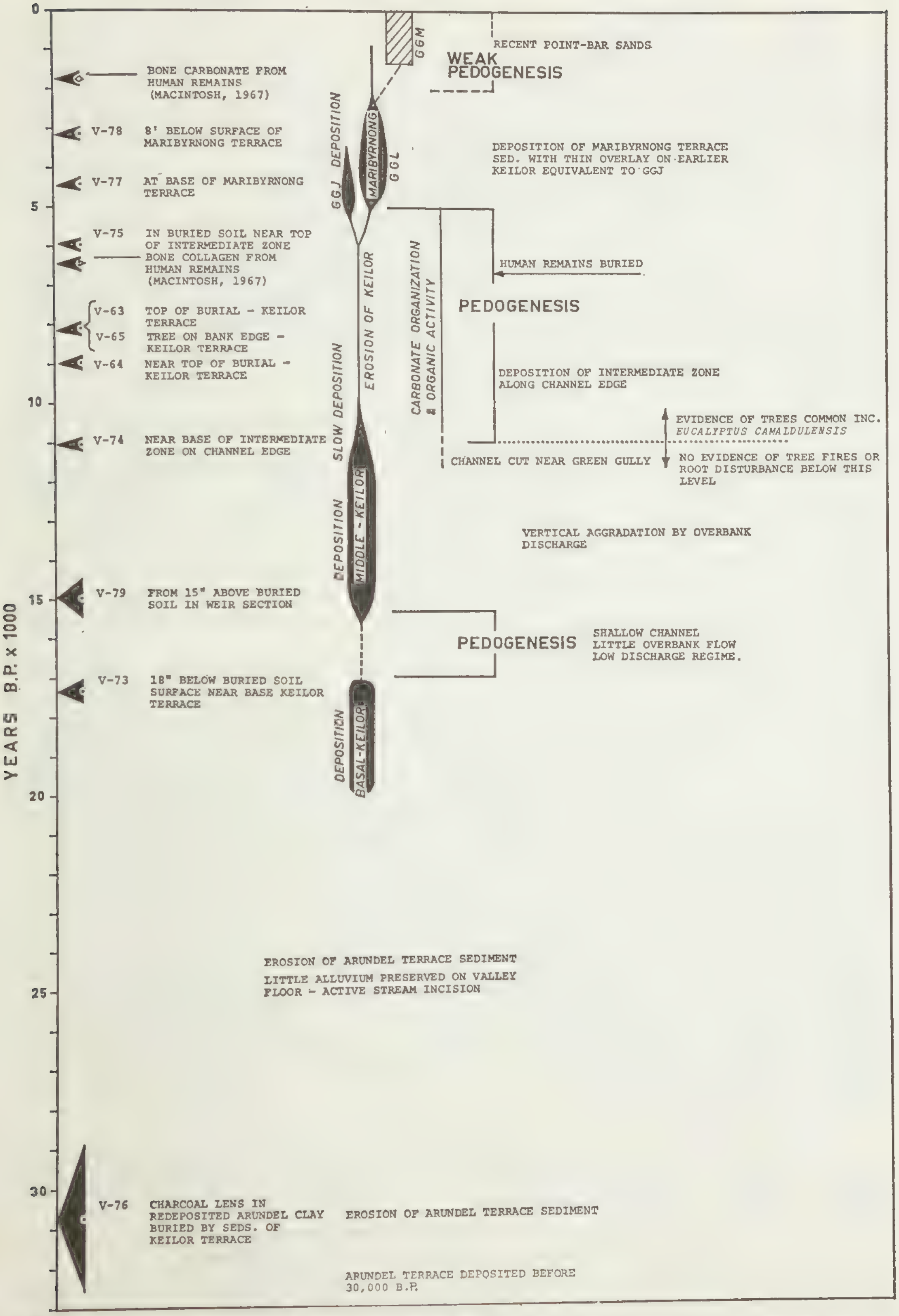


Fig. 22—Diagram summarizing main sequence and radiocarbon chronology of deposition and soil formation in evolution of terraces. Vertical thickness of triangles represents one standard deviation from mean radiocarbon ages.

present mean annual discharge would be accompanied by sediment yields to 25% lower. Low interglacial discharges would be accompanied by sediment yields in the order of 25% higher than present values.

In the terrace sequence, periods of rapid aggradation require rates of deposition in excess of erosion. Such conditions would have existed during periods of high sediment yield assisted by low discharges resulting in high rates of sediment concentration. Thus aggradation was most active during periods of relative aridity. During periods of erosion or floodplain destruction, more sediment was removed than was deposited. This would be favoured by low sediment yields and high discharges. Thus terrace erosion with little floodplain deposition and active pedogenesis, is attributed to periods of lower temperatures or higher rainfall than the present. But in either of these circumstances, whether the floodplain is under the dominant influence of either erosion at one time or deposition at another, both processes may have operated simultaneously. During periods of high discharge and low sediment yield, overbank flow may have produced minor aggradation on the floodplain simultaneous with active floodplain destruction.

On the basis of these relationships, the hydrologic and climatic environments have been reconstructed and correlated with the geological and pedologic events recognized in the sequence as set out in Table 7. In this scheme, the period corresponding to the low temperature-high discharge glacial maximum (from 30,000 to approximately 18,000 B.P.), which from Schumm's data should be a period of erosion, correlates with the major destruction of the Arundel terrace with simultaneous deposition of the basal zone of the Keilor terrace. This agreement between the theoretical and observed data lends confidence to the reliability of the remaining interpretations. The pause in sedimentation with weak soil development bracketed by radiocarbon dates (14,940 and 17,300 B.P.) near the base of the Keilor terrace, corresponds to a stable or transitional phase from a high discharge bed-load regime, to a low discharge suspended-load regime, probably associated with rising temperatures following the cold glacial maximum. Rapid aggradation followed, with active floodplain construction continuing until approximately 12,000 B.P. under the influence of a relatively arid climate with either higher temperatures or lower rainfall than present. Near 12,000 B.P. discharges increased, and channel incision occurred with consequent floodplain erosion. In the absence of frequent overbank deposition, pedogenetic processes, including biotic activity and carbonate segregation, actively developed on the floodplain alluvium keeping pace with slow deposition and resulting in the deep well-organized chernozemic profile. These conditions came to an end soon after 5,000 B.P. with a return to lower discharges and another short period of rapid floodplain construction which extended from approximately 4,500 to 2,000 B.P.

It is not yet possible to correlate precisely this sequence with other climatic terrace sequences such as that of the Shoalhaven River at Nowra (Walker 1962), or with the fluviatile sequence of the Riverine Plain (Butler 1960, Pels 1966). High discharges in sandy bed-load streams have been suggested for late glacial environments of the Goulburn River (Bowler 1967) and Murrumbidgee River (Schumm 1968). Radiocarbon dates from the high discharge phase of the Goulburn, correlate well with the erosion of the Arundel and deposition of the basal Keilor terrace sediment, interpreted here as due to high discharges and low sediment concentration. Moreover, the age of the youngest red-brown earth soils is there placed near 20,000 B.P. as in the case of the Arundel terrace (Table 7), suggesting that with more field evidence it will be possible to correlate in detail the climatically controlled episodes in various basins. Until such data are available from a range of different environments, climatic interpretations based on a single fluviatile system remain tentative.

Conclusions

The major events recognized in the sequence and their radiocarbon chronology ages are summarized in Table 7 and are represented diagramatically in Fig. 22. The Green Gully human remains, the discovery of which initiated the work reported in this paper, were buried in the Keilor floodplain approximately 6,500 years B.P. near the margin of a river channel. Floodplain aggradation had almost ceased some 5,000 years earlier allowing a soil profile to develop on the stable floodplain surface. The grave was cut into this soil and the sediment filling it was itself subject to later pedogenesis before burial beneath younger silts approximately 4,500 B.P.

The stratigraphic units recognized near the soil pit further demonstrate the possible complexity of terrace formation in contrast to the often too simple textbook 'cut-and-fill' explanations. The data moreover raise questions of a fundamental nature about the role of overbank flow as a factor in alluvial aggradation—one often thought to be of relatively minor importance (c.f. Leopold, Wolman and Miller 1964, p. 326).

The cyclic sequence of erosion, deposition and soil formation provides an example of the importance of Late Quaternary climatic change in the pedology and surficial geology of SE. Australia. At the risk of erecting yet another system of inadequate climatic hypotheses, the sequence in this valley can be interpreted in the light of the climatic-hydrologic relationships proposed by Schumm. Using these data, the main periods of aggradation are correlated with high sediment yield, low discharge and high sediment concentration. Conversely, erosion and floodplain destruction are attributed to periods of low sediment yield and high discharge. The former are interpreted as high temperature environments while the latter represent low temperature conditions.

Radiocarbon data establish the age of maximum erosion as being synchronous with the main temperature reduction during the last glacial maximum, lending support to the strength of the climatic interpretations. If the terrace sequence is climatically controlled, it will have its regional representatives in other river basins. Some similarity is recognized to the Goulburn River in N. Victoria, where the radiocarbon ages of both the late glacial high discharge phase of stream activity and the formation of red-brown earth soils resemble those proposed here for the Maribyrnong Valley. But climatic reconstruction based on fluvial evidence, although often used in Australia and elsewhere, is still liable to ambiguity. In the absence of similar sequences repeated throughout a number of drainage basins, the interpretations based on these data remain speculative.

While the interpretations may require amendments or alterations in the light of new evidence from this and other systems, the description of the terraces, their sediments, soils and absolute chronologies provides a basis for comparison with other fluviatile sequences. The account of alternating deposition and soil formation presented here may assist in understanding the relationships between stream behaviour, floodplain construction and soil development in other non-glacial fluviatile environments of SE. Australia.

Acknowledgments

This project was assisted financially in the first instance by the Department of Geology, University of Melbourne, and later, by the Department of Geography, Research School of Pacific Studies, Australian National University. Generous funds from the Sir Ian Potter Foundation financed the stratigraphic excavation without which much of the data in this report would not have been obtained.

My gratitude goes to Professor E. S. Hills on whose initiative the Keilor Project Committee was set up, and to my colleagues on that Committee where mutual

harmony and agreement continued throughout the complexities of project co-ordination. Special thanks are due to those of my colleagues who collaborated both in the field and in the various stages of publication, especially to Messrs D. A. Casey, D. J. Mulvaney, T. A. Darragh, R. J. Lampert and particularly to Miss Anne Bermingham who is responsible, through the Institute of Applied Science of Victoria, for the radiocarbon analyses obtained from samples in the Green Gully area.

Mr E. D. Gill, without whose foresight the human remains may never have been recorded, made available unpublished radiocarbon dates from near Green Gully. In the soil pit, Mr Don Mahon, although frequently interrupted by our activities, remained co-operative at all times. Most laboratory analyses reported here have been carried out by Mr Keith Fitchett of the Australian National University. Mr H. D. Ingle, CSIRO Division of Forest Products, identified the specimen of *Eucalyptus camaldulensis.*

Mr John Knight made available his preliminary survey of the soil pit area while valuable levels and other survey data were provided by Mr J. A. Blackburn. All figures were drawn by the drafting section in the Department of Human Geography, Australian National University. Mr J. N. Jennings and Mr D. J. Mulvaney read the manuscript and offered valuable suggestions for final presentation. Others too numerous to mention assisted in the surveying, in the excavations or in other ways. I trust they will accept my thanks and take heart in the production of this report . . . that all was not in vain.

References

Allen, J. R. L., 1965. A review of the origin and characteristics of recent alluvial sediments. *Sedimentology* 5: 98-192.

Antevs, Ernst, 1954. Climate of New Mexico during the last glacio-pluvial. *J. Geol.*, 62: 182-191.

Bowler, J. M., 1966. Port Phillip Survey 1957-1963: Geology and Geomorphology. *Mem. nat. Mus. Vict.* 27: 19-67.

———, 1967. Quaternary chronology of Goulburn Valley sediments and their correlation in southeastern Australia. *J. geol. Soc. Aust.* 14: 287-292.

———, Mulvaney, D. J., Casey, D. A., and Darragh, T. A., 1967. The Green Gully burial. *Nature* 213: 152-154.

Butler, B. E., 1960. Riverine deposition during arid phases. *Aust. J. Sci.* 22: 451-2.

Butzer, K. W., 1964. *Environment and Archaeology*. London.

Casey, D. A., and Darragh, T. A., 1969. The excavation of the Green Gully burial. *Mem. nat. Mus. Vict.* 30.

Charlesworth, J. K., 1957. *The Quaternary Era with special reference to its glaciation.* London, 2 vols.

Chorley, R. J., 1957. Climate and morphometry. *J. Geol.* 65: 628-638.

Douglas, Ian, 1967. Man, Vegetation and the Sediment Yields of Rivers. *Nature* 215: 925-928.

Dury, G. H., 1964. Subsurface exploration and chronology of underfit streams. *Prof. Pap. U.S. geol. Survey.* 452-B: 56 p.

———, 1965. Theoretical implications of underfit streams. *Prof. Pap. U.S. Geol. Survey.* 452-C:

Fairbridge, R. W. 1963. African Ice-age aridity *in* Nairn A.E.M. (Ed.) *Problems in Palaeoclimatology*, New York, pp. 356-360.

Ferguson, G. J., and Rafter, T. A., 1959. New Zealand C14 age measurements 4. *N.Z. J. Geol. Geophys.* 2: 208-41.

Flint, R. F., 1957. *Glacial and Pleistocene geology*. New York.

Fournier, M. F., 1960. *Climat et érosion.* Paris.

Galloway, R. W., 1965. Late Quaternary climates in Australia. *J. Geol.* 75: 603-618.

Gill, E. D., 1953. Fluorine tests relative to the Keilor skull. *Am. J. phys. Anthrop.* 11: 229-231.

———, 1954. Keilor Man. *Antiquity* 28: 110-113.

———, 1955a. Radiocarbon dates for Australian archaeological and geological samples. *Aust. J. Sci.* 18: 49-52.

———, 1955b. The age of Keilor Man, Australia. *Anthropos.* 50: 417.

———, 1955c. The Australian Arid Period. *Aust. J. Sci.* 17: 204-206.

———, 1956. Radiocarbon dating of late Quaternary shorelines in Australia. *Quaternaria* 3: 133-138.

———, 1957. Current Quaternary Studies in Victoria, Australia. *I.N.Q.U.A. V Internat. Cong., Madrid* 1-7.

———, 1961. Eustasy and the Yarra Delta, Victoria, Australia. *Proc. Roy. Soc. Vict.* 74: 125-133.

———, 1962. *in* A.N.Z.A.A.S. Committee for the investigation of the Quaternary Strandline Changes. *Aust. J. Sci.* 25: 203-205.

———, 1966. Provenance and age of the Keilor Cranium: Oldest known human skeletal remains in Australia. *Curr. Anthrop.* 7: 581-584.

Grant-Taylor, T. L., and Rafter, T. A., 1962. New Zealand radiocarbon age measurements —5. *N.Z. J. Geol. Geophys.* 5: 331-359.

Hills, E. S., 1960. *Physiography of Victoria.* Melbourne.

Keble, R. A., and Macpherson, J. Hope, 1946. The contemporaneity of the river terraces of the Maribyrnong River, Victoria, with those of the Upper Pleistocene in Europe. *Mem. nat. Mus. Vict.* 14: 52-68.

Langford-Smith, T., 1959. Deposition on the Riverine Plain of southeastern Australia. *Aust. J. Sci.* 22, 73-74.

Langbein, W. B., *et al.*, 1949. Annual runoff in the United States. *Circ. U.S. Geol. Surv.* 52: 14 p.

———, and Schumm, S. A., 1958. Yield of sediment in relation to mean annual precipitation. *Trans. Am. Geophys. Un.* 39: 1076-1084.

Leopold, Luna B., Wolman, M. G., and Miller, J. P. 1964. *Fluvial processes in Geomorphology.* San Francisco.

Macintosh, N. W. G., 1967. Fossil man in Australia with particular reference to the 1965 discovery at Green Gully near Keilor, Victoria. *Aust. J. Sci.* 30: 86-98.

Mahony, D. J., 1943. The Keilor fossil skull: geological evidence of antiquity. *Mem. nat. Mus. Vict.* 13: 79-81.

Mason, C. C., and Folk, R. L., 1958. Differentiation of beach, dune, and aeolian flat environments by size analysis, Mustang Islands, Texas. *J. Sedim. Petrol.* 28: 211-226.

Mulvaney, D. J., 1968. Green Gully revisited: the later excavations. *Mem. nat. Mus. Vict.* 30.

Pels, S., 1966. Late Quaternary chronology of the Riverine Plain of southeastern Australia. *J. geol. Soc. Aust.* 13: 27-40.

Polach, H., Golson, J., Lovering, J. F., and Stipp, J. J. 1968. ANU Radiocarbon Datelist II. *Radiocarbon,* 10: 179-299.

Rubin, M., and Suess, H. E., 1955. U.S. Geological Survey radiocarbon dates II. *Science.* 121: 481-88.

Schnell, I. I., 1961. Recent evidence about the nature of climatic changes and its implications. *Ann. N. Y. Acad. Sci.* 95: 251-270.

Schumm, S. A., 1965. Quaternary paleohydrology, in *The Quaternary of the United States* (H. E. Wright, Jr. and D. G. Frey, Eds.), pp. 783-794.

———, 1967. Paleohydrology: Application of modern hydrologic data to problems of the ancient past. *Proc. Int. Hydrol. Symp.* 1: 185-193.

———, 1968. River adjustment to altered hydrologic regimen—Murrumbidgee River and paleochannels, Australia. *Prof. Pap. U.S. geol. Surv.* 598: 65 p.

Schwarzbach, Martin, 1961. The climatic history of Europe and North America, in Nairn, A. E. M. *Descriptive Palaeoclimatology.* New York, pp. 255-291.

Stace, H. C. T., Hubble, G. D., Brewer, R., Northcote, K. H., Sleeman, J. R., Mulcahy, M. J., and Hallsworth, E. G. 1968. *A handbook of Australian soils.* Glenside, S. Aust.

State Rivers and Water Supply Commission, 1964. Victorian River gaugings to 1960.

Sundborg, A., 1956. The River Klaralven, a study of fluvial processes. *Geogr. Annlr.* 38: 127-316.

Walker, P. H., 1962. Terrace chronology and soil formation on the South Coast of N.S.W. *J. Soil Sci.* 13: 178-186.

Explanation of Plates

Plate 2

Upper—Section exposed by completed stratigraphic excavation (cf Fig. 7). Photo by courtesy Director, Institute of Applied Science of Victoria.

Lower—Mahon's soil pit, December 1965, looking NW. along contact between Keilor terrace on left and terrace GGJ on right. The upper section of partially completed stratigraphic excavation is exposed on right, while site of burial excavation is visible on upper left.

GREEN GULLY REVISITED: THE LATER EXCAVATIONS

By D. J. MULVANEY
Australian National University

Abstract

Excavations are described which were conducted subsequent to the removal of the burial. Trenches were located at different localities in order to provide exposed sections at all levels of the Keilor sediments. The stone artifacts recovered were not numerous, but they were comparable from all trenches. Included in the analysis were some tools from Wright's excavation trench (GGW). Trimmed implements in the Keilor Terrace were made on flakes and are typologically classifiable as scrapers. Unexpectedly for an industry of 8,000 years and older, it also included fabricators. The overlying terrace sediments (GGJ) included a microlithic backed blade industry and unifacially flaked pebble tools. These results conform with those made on sites of similar antiquity elsewhere in Australia.

Introduction

The excavations described here were a continuation of the September salvage operation. They served a dual function, for in addition to adding to the cultural material from the site, they were intended to expose sections for geomorphological study. The areas chosen for excavation reflect this duality and while some trenches were archaeologically unproductive, they assisted materially in the geological assessment of the site (Fig. 1).

Excavations extended over almost 5 weeks in November-December 1965, and February 1966. The author supervised part of the first excavation and the whole of the latter; R. J. Lampert directed the remaining period. Unfortunately, the weather which had hampered the September operations, deteriorated beyond expectations. Torrential rain forced suspension of activities on several occasions during December; even in February, 150 points of rain fell on one day. Stratigraphic observation and the collection of charcoal samples for radiocarbon dating was difficult under these circumstances, and the expected volume of excavated material was greatly reduced.

Attention was first directed to an area about 75 ft NE. of the burial site, in order to salvage any evidence before it was quarried away, and to clarify the stratigraphic situation in an area where the quarrying operations had uncovered numerous traces of oxidized sediments and charcoal. The intervening deposit between the burial site and this area having been already substantially removed, it was impossible to correlate the two areas simply by inspection. The presence of a disconformity here was recognized before the excavation began, although its extent and significance in the depositional sequence was a matter for investigation. The importance of this excavation (trenches A and AA) was that it demonstrated that there existed an intermediate zone of erosion and redeposition, separating two bodies of terrace sediment. The upper sediments represented a post-Keilor terrace depositional phase (termed GGJ by Bowler in his contribution to this *Memoir*), while undisturbed Keilor terrace sediments lay below this sloping intermediate zone.

The archaeological finds in the trenches from this intermediate zone therefore lost some of their stratigraphic value, because of the possibility of their mixed origin. It was possible that they had derived through erosion from the earlier terrace

E

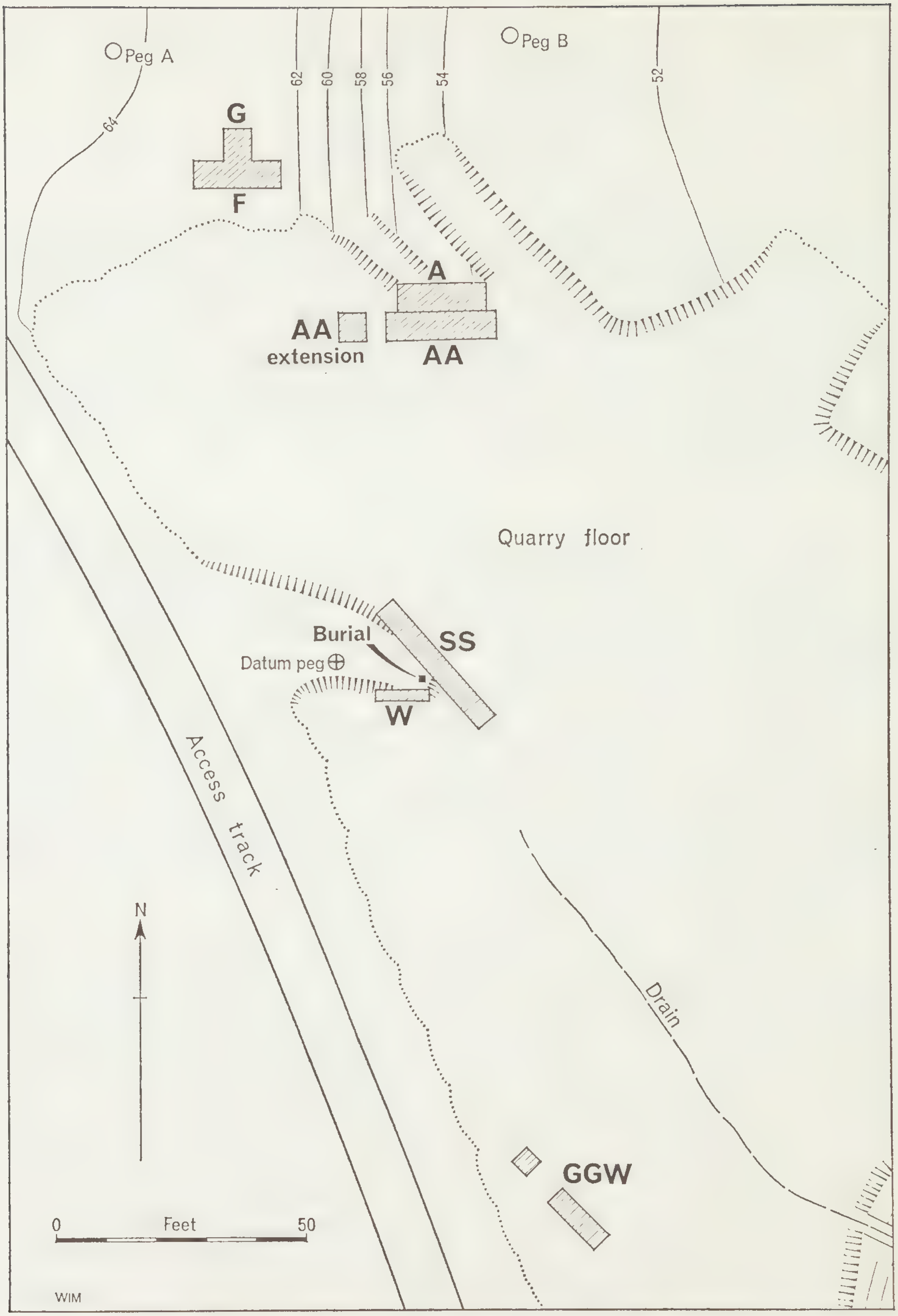


Fig. 1—Plan of site, adapted from Bowler's Fig. 4, showing location of excavated trenches.

or that they related to phases of occupation on surfaces of later GGJ times. However, the determination of the depositional sequence in this area made it possible for R. J. Lampert to select for excavation an adjacent area of undisturbed Keilor sediments, away from the intermediate zone (trenches F, G). His deepest excavation reached R.L. 54 ft.

During February, attention was re-focused on the burial site (SS). R. V. S. Wright's party, in addition to excavating an area of Keilor sediments S. of this site (GGW), had cleared a vertical section immediately NE. of the burial area—by then a rather forlorn residual promontory in the soil pit resulting from the quarrying of the surrounding deposit. The task of extending this vertical face for close study was continued by Mulvaney and a 4 ft wide trench was excavated along the base of the promontory, in a SE. direction. This trench (SS) reached a reduced level of 44 ft (14 ft below the burial) and extended over 16 ft from it. A smaller trench (W) was also excavated along the W. edge of the burial area, to a depth of R.L. 51 ft 6 in. By these means, cross sections through the deposit became available for inspection; the zone of burning adjacent to, and below the burial was exposed on three sides (Fig. 2, pls. 4-6).

At the same time, a test pit 5 ft × 4 ft (later stepped to smaller dimensions) was dug through the lower Keilor terrace sediments. This pit (AA extension, W. of AA), began at R.L. 45 ft and reached R.L. 31 ft 9 in., at which depth the underlying pebble bed was beginning to appear.

It must be emphasized, that although these various excavations were dispersed and each was small in area, their location was determined chiefly by their possible contribution towards assisting the geomorphological reconstruction of the site. They succeeded in this by providing vertical sections through over 30 feet of the sediments, almost 20 feet of which was located at the burial site itself. The archaeological results must be considered partly as incidental to this object.

The sediments were removed in horizontal spits, usually of about three inches in thickness. Many spits proved sterile, and the total number of trimmed artifacts was small. But, when it is remembered that this was an open floodplain, and not a congenial situation to judge from contemporary attempts to camp there, it becomes more a matter for comment that so much occupation occurred there, than that the evidence for it was so meagre.

Burial Site Trenches (SS and W)

Fig. 2* and plates 4-6 present the evidence of the stratigraphy on three sides of the burial site. The details of the burial have been discussed by Casey and Darragh elsewhere in this *Memoir*. It is necessary here to indicate in which ways these later excavations amplified our knowledge of the site.

The band of calcium carbonate, which encrusted artifacts and faunal remains, extended from about R.L. 58 ft 3 in. to approximately R.L. 51 ft. Apart from the sporadic occurrence of stone flakes and implements, the most positive evidence for human occupation on surfaces of the Keilor sediments in this area, consisted of two features which perhaps may be interpreted as hearths. Significantly, they occurred at about the same depth in the deposit, although on opposite sides of the burial area. A confined area of reddened sediments and charcoal was exposed in the NE. trench SS, at R.L. 57 ft (spit 15). Within a few inches, and at the same level, lay some broken fragments of bone, a marsupial vertebra and one small quartzite flake. (It was possible to collect only a very small carbon sample for possible age estimation). Directly underlying this feature, at R.L. 56 ft 5 in, were

*Fig. 2—Sections through burial site looking NE. and NW. Composite result of the initial excavation and subsequent work. This is the same as Casey and Darragh's Fig. 3, which see.

five tiny flakes of quartzite, so close together that they and their carbonate matrix fitted into a matchbox.

In trench W, 10 ft SW. from this feature, and at approximately R.L. 56 ft 9 in., lay a group of weathered basalt pebbles, from 3 to 6 inches across; two of them were cleanly fractured pieces. There were nine stones in all, arranged in circular fashion, while another stone lay five inches above them (Pl. 5). Although no traces of reddened earth and only a few flakes of charcoal were visible within the group, such a concentration cannot be explained as a natural feature, and the possibility that it was a hearth must be considered. One bone was found at the same level, seven inches away. Less than two feet S., and also on the same level, there was another small basalt pebble. At the time of the burial excavation, two similar pebbles were recovered at R.L. 56 ft 8 in., little more than a foot away, during excavation of the S. face of the site. Casey and Darragh observed that at a depth of approximately 56 ft 5 in., a slight scatter of 'flakes, charcoal and granules of burnt earth' occurred along the whole of this face.

The difference in levels between all these features is so slight, that a distinct occupational surface on the Keilor sediments at this time is indicated. It should be possible to date this occupation, because in addition to the carbon sample mentioned above, samples were collected in W trench at about this level, and a further sample AG, was taken on the S. face at R.L. 56 ft 5 in. Unfortunately, all of them are small samples.

Excavations revealed further details concerning the intense burning below the grave by facilitating close inspection of the oxidized sediments in section. There can be no doubt that the burning occurred *in situ* as the surrounding deposit was undisturbed. To judge from appearances (Pls. 3b, 4, Fig. 2), the fuel consisted of tree roots in their position of growth. On the E. face of trench W, there was burning from about R.L. 58 ft 3 in. to below R.L. 56 ft 6 in. In this case, the root had grown between the 'hearth' referred to above, and the isolated stone at the same level. There was no sign of disturbance in the sediments on either side of the oxidized area. On the opposite face of trench W, where the quarrying operations had lowered the surface level to almost R.L. 56 ft, a root-like feature extended from there to below R.L. 53 ft (Pl. 4). During the course of the excavation, it was established that these were continuous features, as they could be followed across the trench. They therefore belonged to the same tree. This evidence is discussed by Bowler in his contribution.

The larger trench (SS) on the SE. side of the promontory, sectioned the remnant of the extensive burning discussed in the report on the burial excavation. It extended to R.L. 52 ft 7 in. Over the last two feet, the burnt sediment was less than six inches in width. For a few inches below this, there were faint traces of burning.

The excavation therefore established that extensive burning had occurred at depths from above R.L. 58 ft down to R.L. 52 ft, and laterally along at least 10 ft at the end of the burial promontory. Because of the initial removal of soil by quarrying, the full vertical distribution of the oxidized sediments, described by Casey and Darragh, is difficult to determine; it cannot be proved that they extended up to the burial. On the other hand, the burnt area sectioned in trench W definitely extended down from about that level. Horizontally, this feature was less than two feet from the grave.

Artifacts from Burial Site

In order to present the stone finds as a useful sample, and because of their proximity and the apparent horizontal nature of the sedimentation, those from the initial burial excavation and trenches SS and W were combined. In Table I all stone finds are tabulated according to relative depth, and the type of raw ma-

terial is indicated. The typology of classifiable artifacts is listed below, although the types and their significance are discussed in a later section.

Trench SS, spit 20, produced the oldest trimmed implement excavated at Green Gully. It is a thick, steeply retouched flake with a rounded end (Fig. 3d.), found at R.L. 55 ft 4 in. A quartzite flake (SS, spit 48) possessing sharp edges and recovered at R.L. 47 ft 8 in., was the earliest excavated flake, positively struck by human agency. It is relevant here to note that the oldest excavated stone came from another area of the quarry, in trench AA (square 8, spit 27). This was a pyramidal chunk of a coarse-grained quartzite pebble (60 × 55 × 43 mm), found at R.L. 40 ft 6 in., but its fracture is best attributed to natural agency. While its base is cleanly fractured, it lacks any traces of percussion or trimming. It should be observed however, that the stone is foreign to the deposit, that its sharp edges preclude the possibility of stream transport subsequent to breakage, and that its companion piece was not found in the vicinity. It must be inferred, in consequence, that the stone was carried to the site, but by means unknown. The date of 17,300 ± 300 B.P. (V-73) was obtained for charcoal from R.L. 42 ft 6 in.

Difficulties in Presentation of Evidence

The numbers of artifacts recovered are relatively few, and the area and volume of excavated material varied, because of the exigencies of the excavation. It is therefore impossible to compare the density of human occupation per unit area or volume. In any case, the area sampled was so small, that no statistically significant artifact collection resulted. The sediments were generally horizontally bedded. Even so, it is possibly misleading to correlate finds at comparable depths from adjacent trenches. The accompanying tables are therefore presented subject to these limitations. The method followed disregards the density of finds, per unit volume, while the numerical count gives equal weight to a trimmed implement, a large flake or a small flake.

Classifiable Implements in Table 1

Spit 1: a broken chert blade, with delicate retouch at its distal end (8 × 7 × 4 mm), best described as a micro-scraper.

Spit 2: the only basalt tool in the collection merits comment, although it can only be classified as miscellaneous. It is a large pebble fragment, 97 × 70 × 31 mm, with some evidence of retouch along one margin.

Spit 3: a quartz piece with one end crushed, or bruised; possibly a flake 'fabricator'.

Spit 7: a small chert piece (Fig. 3a), best described as a 'fabricator' of 'punch' type (*McCarthy et al.* 1946: 34). The identification necessarily remains conjectural, as it is the only example of this sub-type found in the excavations; whereas the type should be bruised on both extremities, only one end is bruised.

Spit 11: a concave scraper (Fig. 3c), and two sizeable fragments of two other broken scrapers.

Spit 13: Two scrapers with pronounced concavities and noses (Fig. 3e, f).

Spit 16: part of a stubby scraper with abrupt retouch at its rounded end; the specimen is probably half of the original tool.

Spit 19: a concave scraper, now broken (Fig. 3b).

Spit 20: a thick, abruptly trimmed scraper (Fig. 3d).

Trenches F-G

These trenches were laid out on the shoulder of a partly bulldozed slope (Pl. 3, Fig. 1). The surface of the terrace (in F, squares 1-4) was undisturbed at

TABLE 1

Stone Artifacts (Burial Site, SS & W Trenches)

Depth R.L.	Spit	A Classifiable Implements	B Misc. Retouch Implements	C Utilised Flakes	D Cores	E Flakes etc.	Material "Chert" A-D	"Chert" E	Quartzite A-D	Quartzite E	Quartz A-D	Quartz E	Igneous A-D	Igneous E
63'-61'8	1	1	3	2	8	94	10	55	4	38		1		
61'2	2		1			1						1	1	
60'8	3			1		16		1		2	1	13		
60'6	4													
60'	5													
59'9	6					3				2				1
59'6	7	1				3		1		2				1
59'3	8	8155 ± 130	1			5			1	5				
59'	9					9				9				
58'9	10	8990 ± 150				4				4				
58'6	11	2	1			3			3	2				1
58'	12				4	5			4	5				
57'9	13	2		1		10			3	5		5		
57'6	14			1		5			1	2		3		
57'2	15		1			5			1	1		4		
56'9	16	2	1			17			2	16	1	1		
56'2	17			2		13			1	4	1	7		2
55'8	18					1						1		
55'5	19	1							1					
55'3	20	1	1			3			2	2		1		
55'	21					2				2				
54'10	22													
54'7	23													
54'5	24													
54'2	25					1						1		
53'11	26					4				3		1		
52'5	32		1						1					
51'11	33													
51'7	34					1				1				
51'3	35													
51'	36					1						1		
50'9	37					1								1
47'8	48					1				1				

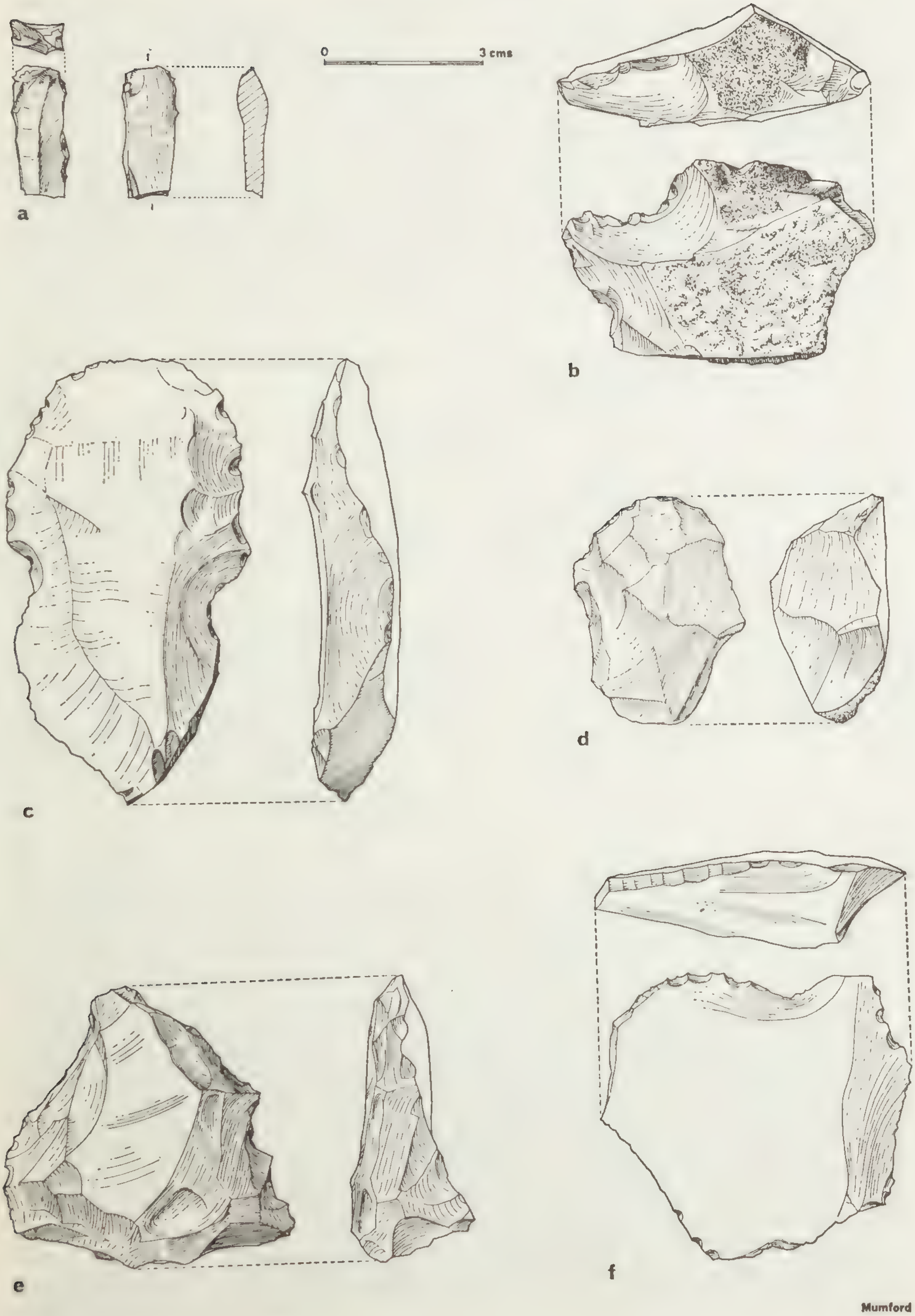


Fig. 3—Selected artifacts from burial area.

R.L. 62 ft, but it dropped sharply at the E. end of the excavation (F, 9-12) where the upper soil had been removed, and the topmost spit corresponded with spit 6 at the W. end. Excavation was organized on a three foot grid. In this area, the top of the calcium carbonate zone was approximately R.L. 61 ft, and all the recognizable artifacts came from within it (e.g. Fig. 6). A further trench, E, was abandoned because of shortage of time and evident disturbance.

It is unfortunate that so much of the soil in this area had already been removed (it was all removed subsequently), so that excavations were limited. There was clear evidence for the intensive occupation of this open site during Spit 4 times (R.L. 60 ft). Whereas all spits excavated below this level produced only sparse material, this spit contained a definite occupational floor. The plan of this floor in trench F, is shown in Fig. 4. Table 2 gives the distribution of stone artifacts in the area, while Table 3 lists all these finds.

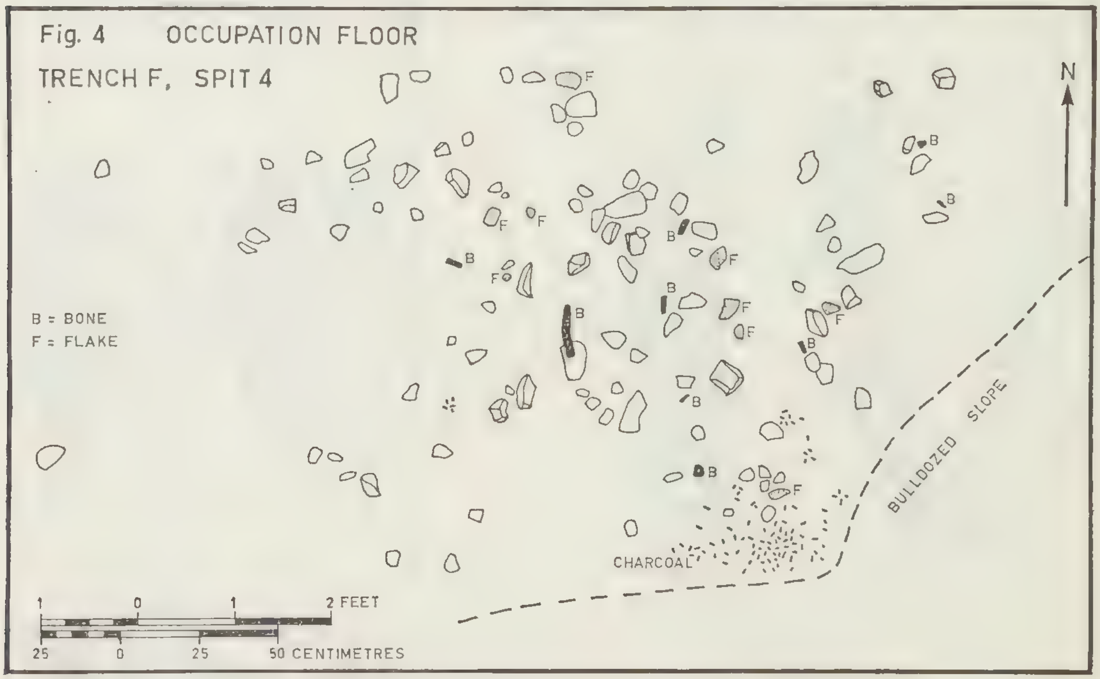


Fig. 4—Plan of 'occupation floor', Trench F, spit 4.

Most of the stone and faunal evidence recovered in the series of excavations here described came from Spit 4. In addition, weathered basalt pebbles, and numerous broken pieces of basalt from 3 to 5 inches across, were uncovered. Their numbers, together with their association with charcoal and burnt earth, renders it probable that some were deliberately placed as 'hearths'. The angular shape of many fractured pieces, also presumably resulted from human activity. It is relevant to mention the probable hearth arrangement in trench W, and the five fractured pieces from above the burial, described by Casey and Darragh, from about R.L. 58 ft. These had been broken from a single basalt rock.

Charcoal from the occupational horizon in Trench F, square 8 Spit 4 was submitted for radiocarbon dating. Its age was 8535 ± 180 B.P. (V-81), which is consistent with the dating from the burial area for a similar flake tool assemblage.

TABLE 2

Distribution of stone artifacts in Trenches F-G, Spit 4

		G7	G5 2 (9)		N
		G8 7 (30)	G6 1 (18)		
F3 (7)	F1 4 (17)	F7 7 (29)	F5 5 (26)	F11 Deposit at	F9 Removed Spit 4
F4 (1)	F2 2 (30)	F8 6 (29)	F6 2 (23)	F12 R e m	F10 o v e d

Each square is 3 ft. wide. Square numbers are indicated in the top left. The number in the centre refers to trimmed or utilized artifacts, while those in brackets are flakes, fragments, etc. All classifiable implements were varieties of scrapers, made on flakes. They are discussed in a later section and some are illustrated in Fig. 6.

Evidence from Other Areas

1. *Trenches A and AA*

During the course of these adjoining excavations, it became evident that this was an area where the Keilor terrace had been eroded, and it was here overlain by terrace GGJ. Bowler describes these later sediments in his contribution to this *Memoir*, and he describes the sloping zone of contact between the terraces, with its numerous patches of charcoal and oxidized sediment (Bowler, Fig. 7).

A number of stone finds was made in this intermediate or contact zone. Unfortunately there is a possibility that either they were deposited on the sloping surface at that time, or they were eroded from the earlier Keilor terrace and accumulated on that surface. Whatever their origin, their chronological status therefore remains dubious. This is unfortunate, as it applies to the only two retouched artifacts found in trench AA—respectively quartz (AA15, spit 26) and quartzite (AA10, spit 10) scrapers. Other finds were made higher in terrace GGJ, which consequently must belong to the period of deposition of that terrace. The most important find in GGJ (A9, spit 6), was a unifacially flaked hornfels pebble (Fig. 5c) measuring 147 × 58 × 39 mm. Flakes had been struck from one end, extending over almost half its area. Including the 3 classifiable implements mentioned, these excavations recovered 4 utilized flakes, 31 quartzite flakes and 8 quartz flakes or small pebbles.

TABLE 3

Stone Artifacts: F & G Trenches

Depth R.L.	Spit	A	B	C	D	E	Waste Material							
		Classifiable Implements	Misc. Retouch Implements	Utilised Flakes	Cores	Flakes etc.	Fine Grained Quartzite		Quartzite		Quartz		Igneous	
							A-D	E	A-D	E	A-D	E	A-D	E
61'6	1					10				10				
61'	2	1		2	4	26			7	25		1		
60'6	F.3	1	3	1		15	2	1	3	13				1
	G.3	6	2	1		72	1	11	7	61				
60'	Spit 4													
	F.1	2		2		17			4	14				3
	F.2	1		1		30			2	28		1		1
	F.3					7				6				1
	F.4					1				1				
	F.5	2		1	2	24		3	7	18				3
	F.6		1	1		23		3	2	20				
	F.7	3	2		2	28	1	3	6	20				5
	F.8	2	1	3	1	23	4	3	3	22				3
	G.5	1	1			9			2	9				
	G.6			1		17	1	3		14				
	G.8	3		4	1	29	1	10	7	19				
59'6	Spit 5													
	F.5		1			19		1	1	17				1
	G.5	1				9			1	8				1
59'	F.6	1	1	1		1			2	1	1			
58'6	F.7			1		2			1	2				
58'	F.8					1				1				
57'6	F.9													
57'	F.10				1	2			1	2				
56'6	F.11	2				1			2	1				
56'	F.12	1				1			1	1				
55'6	F.13			1		2			1	2				
55'	F.14					3				3				
54'6	F.15													
54'	F.16					2				2				

Only one extraneous object was found *in situ* in the underlying Keilor sediments, sufficiently beneath the zone of contact to possess authentic stratigraphic credentials. This was the fragment of fractured quartzite pebble, discussed previously, from R.L. 40 ft 6 in. (AA, spit 27). The age of charcoal from R.L. 42 ft 6 in. was 17,300 ± 300 B.P. (V-73).

In February a test pit (AA extension) was dug three feet W. of trench AA, from the quarry floor (R.L. 44 ft 6 in.) down to R.L. 31 ft 9 in. It measured 8 ×

5 ft at the top, but was subsequently stepped to 4 × 5 ft. Although the trench probed to the base of the Keilor terrace, no artifacts or faunal remains were found. However, there was evidence of burning over the entire floor at about R.L. 42 ft 6 in. and again around R.L. 41 ft 3 in. This consisted of horizons of reddened silt and a few charcoal traces. The coloured material consisted of separate pellets, within an unoxidized matrix. This suggests that the burnt earth must have been redeposited, and as the horizons undulated over a vertical distance of about six inches, the material may have been washed into surface hollows. In any case, there was nothing to positively link the burning with human activities. It may be significant, however, that one burnt horizon lay above the depth (R.L. 40 ft 6 in.) from which came the extraneous quartzite fragment discussed earlier. This was recovered in AA8, no more than 10 ft to the E.

2. *Collection from Upper Terrace, GGJ*

An analysis was made of artifacts collected from the quarry walls, in areas recently uncovered by the quarrying operations. Only those specimens were con-

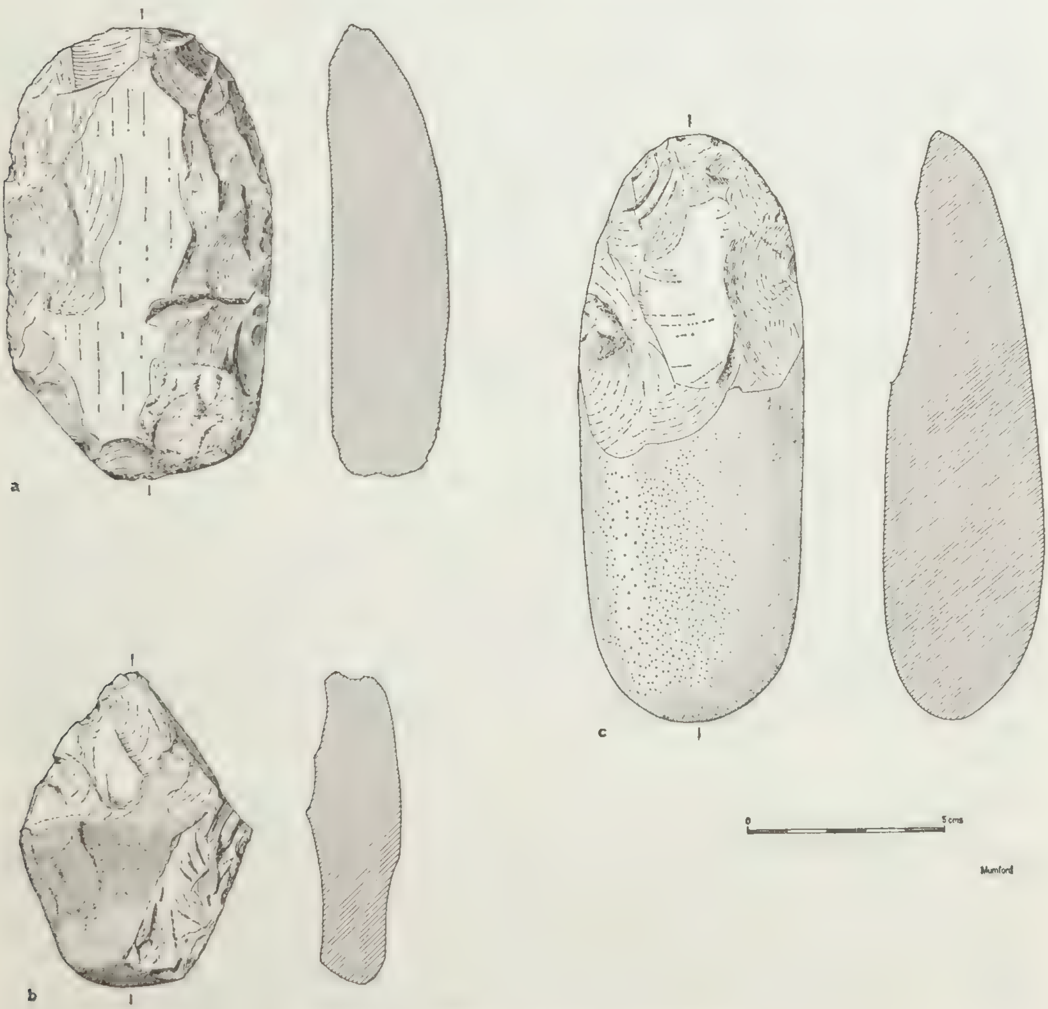


Fig. 5—Unifacially flaked pebble tools.

sidered whose precise location within terrace GGJ was beyond dispute. The finds are made up as follows:

Classifiable Implements	Misc. Retouch Implements	Cores	Untrimmed Flakes			
			Quartzite	Fine grained quartzite and chert	Quartz	Basalt
7	6	7	37	33	3	7

The implements: 2 unifacially flaked basalt river pebbles (Fig. 5a, b), one trimmed around an entire surface, and the second a proken specimen; 1 geometric microlith crescent; 3 large quartzite scrapers and a more delicate chert piece of 'thumbnail' type. Six of the cores were of cherty material, and bore microlithic blade scars. Backed microlithic blades (Bondi points) have been found on other occasions in this deposit. Both in these collections, and from observation of eroded material lying on the surface of this terrace at various places, the striking features are the emphasis on blade production, and the frequent selection of fine-grained raw material. Measurements made on the small samples of waste flakes available demonstrated that those made from chert and fine-grained quartzite tended to be thinner and narrower than those from quartzite.

3. *Collection of Material Eroded from Keilor Terrace*

Various specimens were exposed by the loader, or eroded by heavy rain from recently uncovered Keilor sediments. The trimmed artifacts obtained in this fashion numbered eight. All of them were scrapers, some possessing concavities or projections. In an attempt to delimit the intensity of human occupation from this scatter of eroded material, the relative levels of their occurrence on the quarry slopes were recorded. Nothing was observed below about R.L. 53 ft 6 in., while the main concentration ceased before R.L. 56 ft. Because so much of the topmost soil had been removed, it is impossible to list the upper limit of stone concentration, but its minimum was R.L. 60 ft.

4. *Melbourne Metropolitan Board of Works Trench*

The location of this water-main trench was a few hundred yards S. of the site. It is discussed elsewhere by Bowler. Our attention was directed to a spot where the Keilor terrace was exposed, above the Arundel terrace. In the face of the trench, and *in situ* in the Keilor terrace was a charcoal concentration containing a few heavily mineralized bone fragments. It was definitely associated with a human industry; 26 quartzite flakes were recovered, several of which possessed bulbs of percussion, together with a fragment of a trimmed quartzite artifact, almost certainly a scraper. Charcoal was collected for C14 estimation, but results are unavailable.

Beneath the Keilor sediments was a pebbly bed of distinctive red colour. It contained a continuous string of burnt earth particles and charcoal scatter, along several feet of the wall. While some of this may have been produced *in situ*, it looked more like a loose accumulation, perhaps at the foot of a slope (much of the oxidized material was in separate, disjointed concentrations). Amongst this mass of stone rubble were pieces of fractured quartzite. The edges of some are sharp and the fractures are clean. On examination, it is apparent that these pieces resemble many other specimens collected in the soil pit from the pebble bed at the base of the Keilor terrace in trench AA. Comparable specimens were also selected

from the mass of stone on the banks of Green Gully creek, where it has exposed the same pebble bed. In the light of tests suggested by J. D. Clark (1961) and Mason (1965), all this material was examined in order to ascertain whether it was fractured by man or nature. The conclusion is that natural circumstances were responsible in every instance. It is proposed, in future, to make this problem the subject of a separate study. A brief summary of the reasons for this conclusion is given here, although it is realized that the sample studied was selectively collected, and that until the evidence is described, this remains an opinion only.

There are few bulbs of percussion or striking platforms, and some of them are in impossible positions for human handling. The angles of primary fracture (on almost any edge selected) approach verticality in reference to the striking platform, a feature which in the studies listed above is attributed normally to natural processes. Even the few specimens which bear superficial resemblance to retouched artifacts, are really only fortuitous. The edges are 'nibbled' or bruised through pressure, and they bear steep, intermittent fractures. In some cases, the differential patination proves that this 'trimming' belongs to different periods in the history of the specimen, and that the end-product is simply the result of many accidental fractures. This is certainly the case with one quartzite piece which bears superficial resemblance to an Acheulian hand axe, for it is evident that at least two distinct occurrences of 'flaking' occurred later than the initial accident which shaped it. Both on 'cores' and 'flakes' many scars are concave and saucer-shaped, i.e. they have lifted out from the mass due to thermal fracture. Unfortunately, the quartzite in question is so coarse-grained that the diagnostic rings of fracture are not present to clinch this argument. In all cases like this, where there is no indication of purposeful trimming or design in a fractured stone, such objects cannot be accepted as artifacts unless they are associated with undoubted specimens which have been artificially fabricated. They *may* be artifacts, and they equally well may *not*.

Raw Material of the Stone Industries

Analysis of the stone implements and waste products, revealed changing preferences or availability of stone supplies. Table 4 presents this in tabular form, although attention is directed to the smallness of the sample in most cases. For comparative purposes, the material is tabulated as for each six inches of depth, and Wright's material from GGW excavation is included. The sporadic occurrence of primary flakes of igneous rock has been excluded; none possess traces of grinding.

The points of significance are the indication that the use of chert is limited to the occupation above R.L. 61 ft, while the fine grained quartzite does not occur much below R.L. 60 ft. (There is one implement in GGW of fine grained quartzite, but it occurs also above R.L. 60 ft). At the same time, the preference for chert in the topmost deposit is marked by an avoidance of quartz. The fact that chert and fine-grained quartzite are common in the later terrace, GGJ may have cultural implications.

Artifact Typology

1. *Terrace GGJ*. These investigations have recovered three unifacially flaked pebble tools (Fig. 5), and definite evidence for a microlithic backed blade industry in this terrace. As this material has affinities with the cores, flakes and raw material preferences, excavated above R.L. 61 ft (in SS and F-G excavations), it is a reasonable hypothesis that they belong to the same culture and chronological age.
2. *Keilor Terrace*. In Wright's excavation, classifiable tools consisted of scrapers, both large and 'thumbnail' types, and 'fabricators'. Areas SS and F-G pro-

TABLE 4

Distribution of raw material: total numbers according to depth. It is emphasized that, although stratigraphic equivalence between these areas is probable, it has not been established by excavation, as intervening deposits had been removed.

Depth	Composite, burial and F-G areas				Area G.G.W.	
62'	60		48	1		
		2	27	14		
	1	17	80			
60'		40	200	2	62	2
		3	30		266	79
		1	17	1	410	122
			12		156	85
58'			6		36	110
			11	8	18	18
			4	4		
			26	8		
56'			2	1		
			4			
			9	1		
54'			2	1		
				1		
			3			
52'			1			
50'						

duced 36 diagnostic artifacts below R.L. 61 ft. These consisted of two possible fabricators, and the remainder were scrapers, intact or broken; there were no 'thumbnail' types.

The Scrapers. For purposes of analysis, incomplete specimens were rejected, but Wright's 'large' specimens were amalgamated with the collection. This resulted in a total of 42 for examination. Generally, they were an undisciplined group, few of them conforming readily to the designations 'side', 'end', and so on (Figs. 3, 6).

It was decided to describe some of their characteristics metrically, and the results are illustrated in Fig. 7. Wright's group of 'thumbnail' scrapers was excluded from the analysis, as there were none recovered in these excavations. It is realized that any presentation which lumps together artifacts separated in vertical distance by up to six feet, and in time perhaps by millennia, possesses many pitfalls. It must be stated simply, that the author was aware of this, and could find no significant variation with depth. The sample is a small one, however, and at some levels it is totally inadequate for comparison. The assemblage of scrapers shows definite modes, both in regard to length and width. There is also an interesting correlation between length and width. Of the 31 specimens between 3 and 5 cm length, 26 of them fell between the same dimensions of width; only 4 of 28 examples 3 to 4·5 cm long fell outside the same range in width.

There were two visual observations meriting comment. Eighteen specimens possessed distinct concavities on the working margin, most of them having corresponding projections or 'noses' (e.g. Fig. 3b, c, e, f). These were represented at almost every depth. The other feature was that four specimens had been trimmed reversely. That is, on opposite ends of the flake, alternate faces had been trimmed (e.g. Fig. 6c, e, f).

The Fabricators. Wright has discussed this type in his report, in which he discusses definitions by McCarthy, *et al.* (1946: 34). One of the specimens from SS spit 2 is not a very convincing example. A quartz piece, it measures 23 $\times$ 19 mm and is roughly rectangular in shape, but it possesses a bruised or fractured edge on one end only. The second example is possibly one of McCarthy's 'punch'-type fabricators (Fig. 3a). If so, it is the only example excavated at Green Gully. It is made from fine-grained quartzite, and is distinctly splintered on both sides of the distal end. The other end is not fractured, which makes the attribution rather conjectural.

Cultural Affiliations of Green Gully Prehistory

The Green Gully burial took place at a period when the stone equipment of the inhabitants consisted of a variety of scrapers (both large and small) and fabricators. There is nothing in the meagre evidence at this site to indicate the possession of other stone tools by campers on the Keilor terrace. It is only at the top of those sediments, perhaps at a period related to the deposition of terrace GGJ, that the stone culture changed markedly. At that time, the selection of different raw material, a new technology producing thinner blades and delicately retouched backed tools, characterized a different industrial practice. This was the period, also, of the use of unifacially flaked pebbles (the sumatraliths of earlier writers). This microlithic blade industry, and occasional uniface pebble tools, are associated with the top of the Keilor sediments and the more recent terraces at other localities in the Maribyrnong River valley, including the locus of the Keilor cranium.

Distance renders comparisons unsound, but the sequence, with a scraper assemblage preceding one containing backed blades, recalls the Kenniff Cave pattern, which I tentatively designated non-hafted and hafted (Mulvaney and Joyce 1965). Indeed, the similarity between the scrapers from Green Gully and Kenniff Cave is striking, although it is emphasised that the minute 'thumbnail' scrapers did not occur at Kenniff. Figure 7 presents a summary of the Kenniff evidence for comparison. The Kenniff results are somewhat distorted by the unique character of the latest occupation, which produced extremes in scraper dimensions. However, if the lowest 42 scrapers from Kenniff are examined, they fall even further within the limits of the Green Gully material. As some of the Green Gully evidence must be older than 9,000 years, this result is interesting in view of the Pleistocene antiquity of the Kenniff material. It is relevant, also, that the earlier layers at

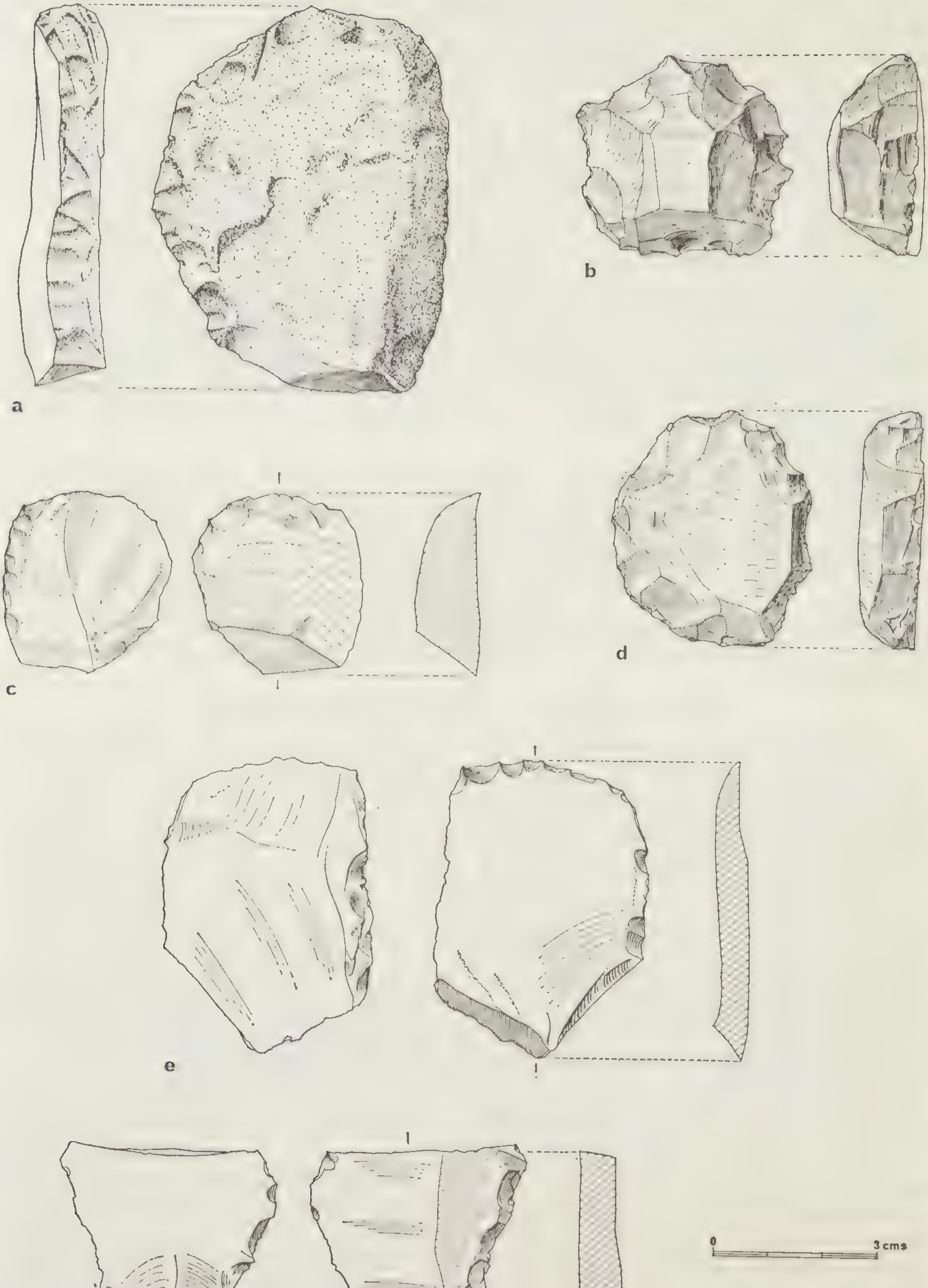
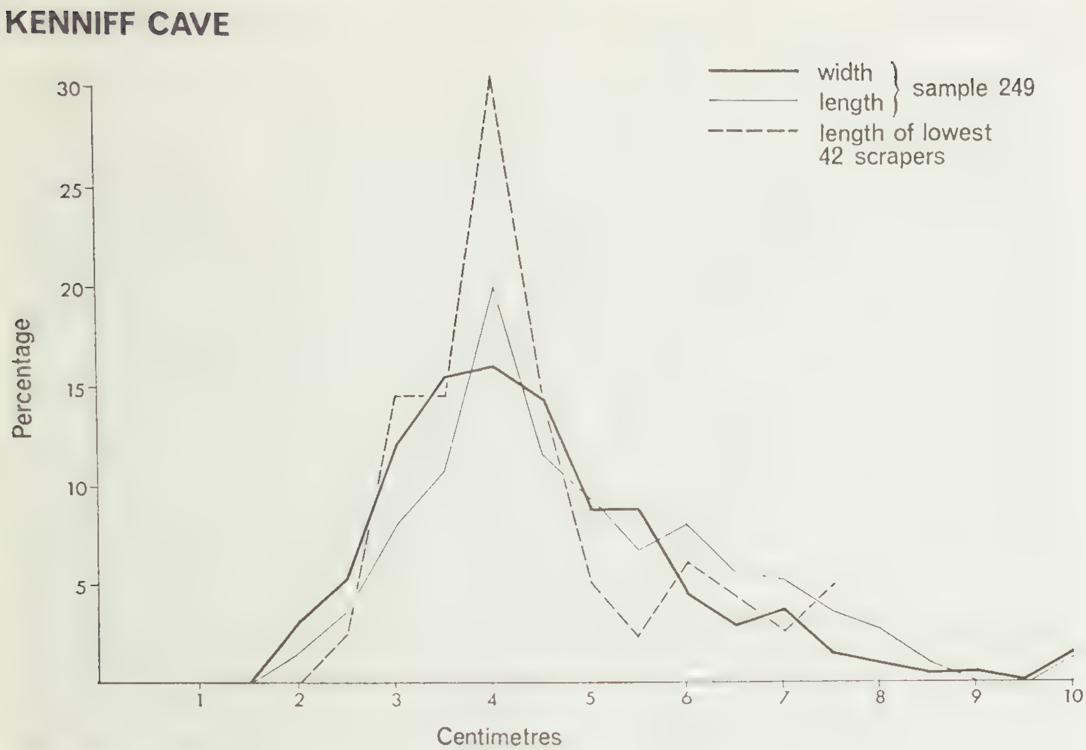


Fig. 6—Selected artifacts from Trenches F and G.



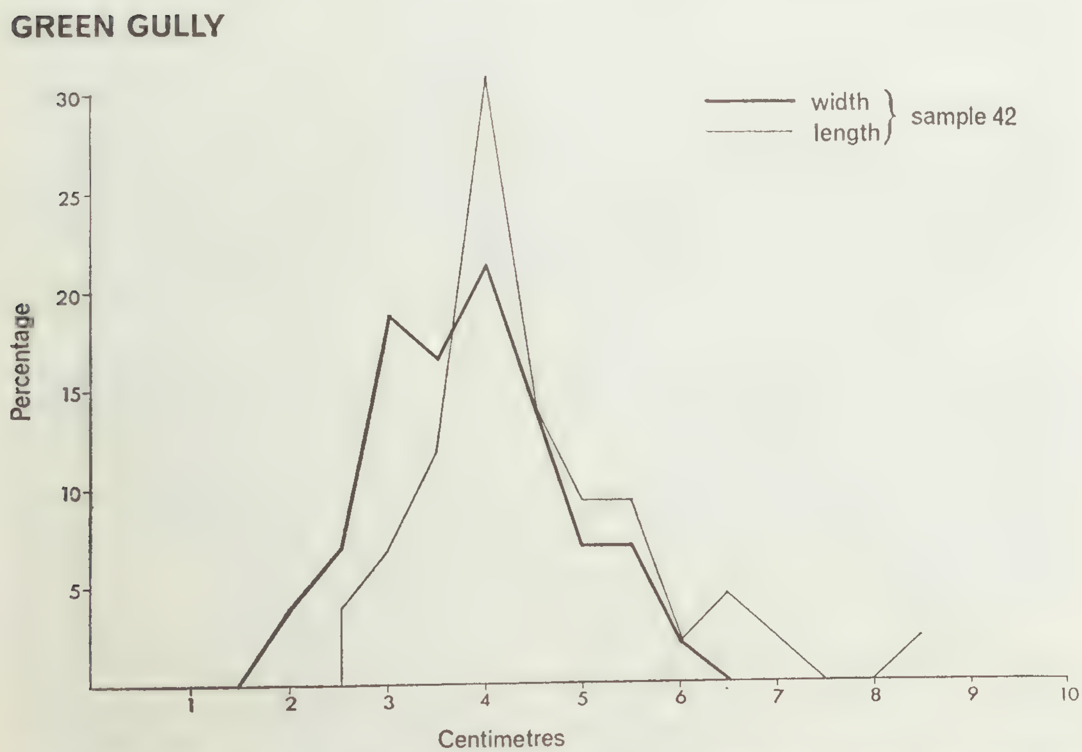


Fig. 7—Metrical record of Green Gully 'scrapers' compared with the evidence from Kenniff Cave.

Kenniff were characterized by an emphasis upon the use of scrapers of concave form.

It may be countered, that the resulting measurements are merely the essentials of 'scraperness', and that rather than cultural determinants, scrapers anywhere would approach similar form. Unfortunately, few comparative treatments have been published, but those which have are varied in result. Dr Isabel McBryde (1966) presented a totally different pattern (smaller) of length and breadth for her 74 scrapers from Seelands. Higgs *et al.* (1960, 219), demonstrated that English stone industries show preferential bias, although this Hurst Fen pattern closely resembles the Kenniff one. On the other hand, Higgs *et al.*(1964, 244) analyzed 117 scrapers from Kokkinopolis, Greece. Although their thickness is comparable to the Green Gully collection, they are longer. One of the interesting features of this English evidence is that it proves that significant variations occur between scrapers made in the same region from identical raw material by different cultures, yet the same culture produced comparable scrapers 150 miles apart. Here is an apparent example of prehistoric fashion affecting typological behaviour.

The discovery of fabricators at Green Gully introduces a new element into the prehistoric technology of the site, and into prehistoric Victorian reckoning. They were not identified at Kenniff Cave, and have been considered a component of the Bondaian, or more recent cultures of the E. seaboard. However, they are fairly ubiquitous in the European and African Palaeolithic, and they may have a respectable antiquity in Australia. At Capertee (McCarthy 1964, table 3), although rare in lower levels, there are four specimens which must be considerably older than 3623 $\pm$ 69 B.P. (V-34), and possibly almost as ancient as 7360 $\pm$ 125 B.P. (V-18). At Graman, New England, the type may go back 4500 years (McBryde 1966).

The fact that the type appears in some industries and not in others is probably significant. On the other hand, the nature of its significance remains to be determined. Classifiable artifacts normally have been shaped to a predetermined pattern—the trimming precedes their use as tools. The reverse seems to apply to the fabricator. It was not deliberately trimmed, although preference may have been given to a rectangular shaped primary flake. The characteristic bruising and spalling on opposite ends was simply an incidental result of its use. All that can be inferred from such evidence is that the stone may have been deliberately selected (though not necessarily manufactured) because its shape rendered it useful for some function. In the course of its use (and this may have covered a multitude of purposes) it must have been battered and bruised. Is it therefore correct to consider it as a *cultural* indicator, or was it simply technological—a useful working device, which was part of the stock-in-trade of any stone worker? Given the unorthodox method of producing this 'type', it is necessary to be stringent in classifying it. Unless definite bruising is evident on at least two opposed margins, examples should not be classified as fabricators. In other words, similarities may be a function of the principle of limited possibilities, and not a reflection of cultural diffusion. These comments were advanced before Wright's analysis was available; although his arguments are cogent I prefer to let these observations stand.

The evidence from Green Gully is meagre, but interesting and consistent. From what is known of the chronology of backed blade and unifacial pebble industries in Australia, it is to be expected that they post-date 8,000 years. The Kenniff sequence is witness to the longevity of the scraper as a cultural possession. One new element (though not found in the Kenniff excavations) is the 'thumbnail' scraper, and the other is the fabricator. It remains for future excavations in SE. Australia to determine whether this pattern of a flake tool (scraper) industrial

tradition, followed by cultures utilizing pebbles and blades has a wider distribution. The status of the fabricator is a further problem awaiting investigation.

Acknowledgments

I examined R. V. S. Wright's GGW collection, and I gained much from discussion with him. Mr F. D. McCarthy examined my own collection and offered valuable advice. R. J. Lampert and Miss W. Mumford, both of the Department of Anthropology, A.N.U., assisted in many ways; their essential co-operation is gratefully acknowledged. Those who assisted in the field are too numerous to mention individually, but four participants must be singled out for their assistance with this part of the project—J. M. Bowler, D. A. Casey, C. A. Key and R. J. Lampert. I am grateful to Anne Bermingham, Institute of Applied Science of Victoria, for her assistance at the site and in the radiocarbon laboratory.

References

CLARK, J. D., 1961 Fractured chert specimens from the Lower Pleistocene Bethlehem Beds, Israel. *Bull. Br. Mus. nat. Hist. Geol.* 5.

HIGGS, E. S. *et al.*, 1960. Excavations at the neolithic site at Hurst Fen, Mildenhall, Suffolk. *Proc. prehist. Soc.* 26: 202-245.

————, 1964. The Climate, Environment and Industries of Stone Age Greece. Ibid 30: 199-244.

MASON, R. J., 1965. Makapansgat Limeworks fractured stone objects and natural fracture in Africa. *S. Afr. archaeol. Bull.* 20: 3-15.

MCBRIDE, Isabel, 1966. *An Archaeological Survey of the New England Region*. Ph.D. Dissertation, University of New England Library.

MCCARTHY, F. D., 1964. The Archaeology of the Capertee Valley. *Rec. Aust. Mus.* 26.

————, BRAMELL, E., and NOONE, H. V. V., 1946. The Stone Implements of Australia. *Mem. Aust. Mus.* 9.

MULVANEY, D. J., and JOYCE, E. B., 1965. Archaeological and Geomorphological Investigations on Mt. Moffatt Station, Queensland. *Proc. prehist. Soc.* 31: 147-212.

Explanation of Plates

PLATE 3

a (upper) Green Gully soil pit looking N. before the February1966 excavations at the burial site. The burial promontory is on the left centre, trenches A and AA right lower centre, and trenches F and G upper centre. GGW trench was sited outside this view to the left foreground. The trees in the right centre line the Maribyrnong River, and Green Gully runs across the middle distance in front of them.

b (lower) Trench W, looking SW. The burnt root and oxidized sediment on the opposite side of the trench to 2a.

PLATE 4

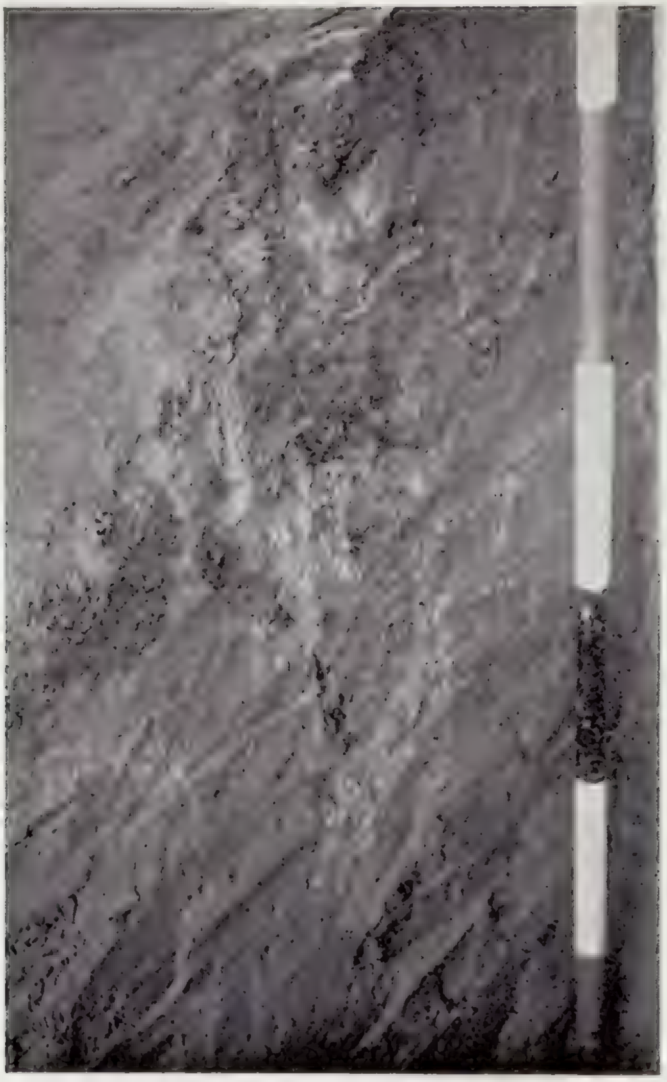
Trench W, looking NE. The pale discolouration on the right centre is oxidized sediment, the presumed burnt tree root. The 'hearth' is appearing in the centre. A small basalt piece lies immediately to the right of the root.

PLATE 5

Trench W, 'hearth' arrangement of basalt fragments, fully excavated. It lay at a level earlier than the burial surface.

PLATE 6

Looking S. along trench SS. The level of the burial approximates to the ledge, top right.



FLAKED STONE MATERIAL FROM GGW-1

By R. V. S. Wright

Introduction

The intention of this excavation was to acquire as complete a collection of archaeological remains as possible from a sample of the deposits of the Keilor terrace. Mulvaney had carried out, and was to carry out, laborious exploratory excavations to establish the general relationship of artifacts to deposits in this terrace. Since I had an ample labour force from students of the Department of Anthropology at the University of Sydney I decided to concentrate my efforts on a limited volume of deposit. The intensive examination of this intractable deposit means that we can make a confident statement about a total industry from the Keilor terrace. Small objects in the sample excavated should be at their true proportionate frequencies compared with the larger, more readily recovered, objects.. Mulvaney's more extensive exploration is thus complemented by this intensive examination.

Designations

I named the area excavated GGW-1. This signifies Green Gully, Wright's first excavated area. To serve as a local datum point I put an aluminium tube into the ground. This point has been defined in relation to other fixed points in the area. Its level is related to the datum at the skeleton site of 64·56 feet. I used my datum in dividing the site into areas two feet square. These areas are designated by their corners closest to the datum. Thus SE16/NE2 designates the area whose nearest corner is 16 ft SE. and two feet NE. of the datum. The datum also served for designating levels, which can be related to those elsewhere in the Green Gully excavations.

Methods of Excavation

The deposit was divided into horizontal spits six inches thick. The top and bottom limits of each spit were kept the same over the whole excavation. Given the supposed origin of the sediments, this method presumably provides the best reconstruction of chronology. However, I could see no visible stratification in the sediments to provide a check on this assumption. Although the spits are constant in elevation they were not excavated in one operation over the trenches. The site was divided into areas two feet square and the contents from each spit within a particular area were kept separate. Three-dimensionally, the site can thus be regarded as a series of progressively excavated columns.

A single spit from a single area I have called a *unit* of excavation. This is the portion of soil on the site from which the contents have been bagged as one. A unit is thus two feet square by six inches deep, making a volume of 2 cu. ft. It is designated horizontally and vertically, e.g. SE6/NE0—Spit 5. Artifacts from this excavation cannot be more precisely located than by these units of soil from which they were removed.

I ensured a constant level for spits by using a level and staff. Plumb-bobs were used to obtain vertical walls for each cutting. This means that the volumes of the units are reasonably constant and the lower units are not reduced in volume by walls sloping inwards.

The deposit was compact and hard when dug, readily fracturing into large lumps

on excavation. To prevent damage to the edges of flaked stone artifacts by scraping with a trowel I tried to remove the deposit in lumps as large as possible. After removal these were carefully crushed in a plastic basin before being sieved. All soil was sieved through a quarter inch square mesh.

TABLE 1

SE28 /NE0	SE26 /NE0	SE24 /NE0	SE22 /NE0	SE20 /NE0	SE18 /NE0	SE16 /NE0		SE8 /NE0	SE6 /NE0
SE28 /NE2	SE26 /NE2	SE24 /NE2	SE22 /NE2	SE20 /NE2	SE18 /NE2	SE16 /NE2		SE8 /NE2	SE6 /NE2

TABLE 2

The reduced levels are the same as for Mulvaney's excavations. Wright's spit numbers do not coincide with Mulvaney's

Spit No.	Reduced Level
1.	61 ft 0 in.-60 ft 6 in.
2.	60 ft 6 in.-60 ft 0 in.
3.	60 ft 0 in.-59 ft 6 in.
4.	59 ft 6 in.-59 ft 0 in.
5.	59 ft 0 in.-58 ft 6 in.
6.	58 ft 6 in.-58 ft 0 in.
7.	58 ft 0 in.-57 ft 6 in.
8.	57 ft 6 in.-57 ft 0 in.
9.	57 ft 0 in.-56 ft 6 in.
10.	56 ft 6 in.-56 ft 0 in.
11.	56 ft 0 in.-55 ft 6 in.
12.	55 ft 6 in.-55 ft 0 in.

A mechanical excavator had previously removed some two or three feet of soil from above the area I excavated. This work had left as a slope the undisturbed surface on which I started excavating. Spits 1 to 4 tended to be incomplete over the site and their degree of incompleteness varied. Spits 1 and 2 scarcely existed; Spit 3 had been largely removed but in some units up the slope (NE0 units) more than half was left. Spit 4 was nearly intact except for a few downhill units where up to two thirds had been removed. Spit 5 was complete, as were all spits below. Before starting to excavate the spits, I removed the loose debris from the surface of this slope.

Correction Factors for Contents

By computing the proportion of soil remaining in incomplete units it has been possible in some cases to apply correction factors so as to estimate better the contents before disturbance. Some uses of this correction factor occur below. Not too much reliance should be placed on the precise values of the corrected figures. Nevertheless they must be in all instances closer to reality than the actual figures. Where proportions of things actually recovered within each unit are discussed, the corrected figures are irrelevant and the actual figures have been used.

Trial Sounding

The area GGW-1 was selected because of the quantity of flakes eroding out of the soil on the artificially exposed slope, presumed to be sediments of the Keilor terrace in which the burial had taken place. The first columns excavated were

furthest from the datum point. They formed a square 4 × 4 ft and contained areas SE26/NE0, SE26/NE2, SE28/NE0 and SE28/NE2. I excavated these to a depth of nine feet. This trial sounding showed that artifacts were concentrated near the top and that the deposit could be assumed to be unrewarding below Spit 7. Spits 9 to 11 had no flaked stone, Spit 12 had 3 pieces, and Spits 13 to 19 (19 was the lowest spit excavated) had no flaked stone.

Since a prime purpose of my work was to obtain a comprehensive stone industry I did not excavate below Spit 7 when extending the excavation.

TABLE 3

Spit 1	1	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Spit 2	3	4	1	-	-	-	-	25	27	3	4	1	-	-	-	-	25	27
	2	2	-	-	-	-	-	-	-	2	2	-	-	-	-	-	-	-
Spit 3	20	30	46	23	24	49	52	25	34	20	33	64	48	84	142	151	38	48
	6	7	4	-	-	-	-	18	7	12	13	25	-	-	-	-	18	65
Spit 4	46	45	46	40	26	17	3	9	11	46	45	46	44	29	19	3	9	11
	50	67	49	22	13	28	26	11	23	55	67	64	59	35	78	65	18	35
Spit 5	17	13	14	11	6	12	11	1	5	17	13	14	11	6	12	11	1	5
	24	37	19	19	11	6	29	3	3	24	37	19	23	13	7	29	3	3
Spit 6	15	17	13	16	19	1	4	12	8	15	17	13	16	19	1	4	12	8
	9	4	6	2	10	2	3	3	2	9	4	6	2	10	2	3	3	2
Spit 7	2	5	1	2	2	0	0	1	0	2	5	1	2	2	0	0	1	0
	7	4	2	2	4	1	2	1	0	7	4	2	2	4	1	2	1	0
Spit 8	2	1	-	-	-	-	-	-	-	2	1	-	-	-	-	-	-	-
	4	5	-	-	-	-	-	-	-	4	5	-	-	-	-	-	-	-
Spit 12	0	0	-	-	-	-	-	-	-	0	0	-	-	-	-	-	-	-
	1	3	-	-	-	-	-	-	-	1	3	-	-	-	-	-	-	-

Distribution of pieces of flaked stone by units. For each spit a miniature plan of the site has been drawn and figures entered for each area. Designations of areas can be worked out from Fig. 1. The totals for each spit are given in Fig. 4. A dash means either no deposit was present (i.e. Spits 1-3) or the deposit was there but not excavated (i.e. Spits 8 and 12). A nought means the unit was excavated but contained no flakes.

As noted in the comments on Tables 3 and 4, the pieces of flaked stone at GGW-1 reach a peak in Spit 3 at R.L. c. 59 ft 9 in. Below R.L. 59 ft 3 in. the fall-off is marked. This pattern mirrors well that presented by Mulvaney in his Table 3. This correspondence is confirmed when we consider two further categories—pieces of basalt and the bones. Mulvaney observed intensive occupation at R.L. 60 ft in his Trenches F and G. Besides the concentration of flaked stone, there were concentrations of broken pieces of basalt and of bones.

At GGW-1 the pieces of basalt were counted and occur as follows for corrected figures: 3 (139), 4 (129), 5 (19), 6 (21), 7 (5). The pieces varied in size, the largest being a complete boulder weighing 18 lb. in Spit 4.

At GGW-1 fragmented bones, while reaching a peak at R.L. 59 ft 3 in., do not show such a clear trend as the basalt does. There are clearly two concentrations separated by a relatively barren level. Corrected figures are: 3 (163), 4 (344), 5 (26), 6 (198), 7 (48).

Raw Materials

Using the criterion of flaking characteristics, the raw materials can be readily divided into two rock types:

1. 'Quartzite', etc. (including 'chert') homogeneous with few irregularities in its structure to obstruct flaking intentions. Small to large flakes were produced.
2. 'Quartz' crystalline, with many irregularities in its structure to affect flaking intentions. Only relatively small flakes were produced.

There are changes in the proportions of these two materials through the spits.

TABLE 5

Spits	Total flaked pieces	Quartz	Quartzite etc.	% Quartz to total of spit	% Quartzite etc. to total of spit
2.	64	2	62	3%	97%
3.	345	79	266	23%	77%
4.	532	122	410	23%	77%
5.	241	85	156	35%	65%
6.	146	110	36	75%	25%
7.	36	18	18	50%	50%
	1,364	416	948		

Total of Quartz as % of total flakes = 31%
Total of Quartzite, etc. as % of total flakes = 69%

Sizes and Shapes of Flakes

To assess size and shape observations were made on the contents of areas SE26/NE 0 & 2, SE28/Ne 0 & 2. 409 flaked pieces, both broken and complete, were measured. About 55 per cent are below 2 cm in maximum dimension. 86 per cent are below 3 cm. Only between 1 per cent and 2 per cent are 5 cm or more. It is thus not a collection with a conspicuously large component. Of these 409 pieces 71 are complete flakes. Breadth as a percentage of oriented length approximates a normal distribution with a mean of 101·4 per cent and a standard deviation of 24·6 per cent. Thus the flakes tend to be of equal length and breadth and no special 'blade' grouping occurs.

State of Preservation

The flake scars on the artifacts are not abraded along the separating ridges. It thus looks as though the artifacts are *in situ* in the deposit.

TABLE 4

Spits	Actual totals for spits		Corrected totals for spits
1	1		>1
2	64		>64
3	345	most of deposit already removed	>761
4	532	73% deposit left	728
5	241	97% deposit left	248
6	146	all deposit left	146
7	36	all deposit left	36
8	12	only 4 areas dug	12
12	4	only 4 areas dug	4
	1,381		>2,000

Tables 3 and 4 show:

1. The actual number of pieces of flaked stone recovered in Spit 3 is less than in Spit 4. However, the corrected figures show that Spit 3 is richer. Whether the increase continues upwards into Spits 2 and 1 it is not possible to say.
2. From Spit 3 downwards there is a progressive decrease in the numbers of pieces present.
3. In each Spit the pieces are not evenly distributed horizontally, but are patchy. Sometimes there are marked discrepancies between adjacent units. This is most noticeable in Spit 4 SE16/NE0 and SE16/NE2 where the discrepant figures are exaggerated by correction to 3 and 65 pieces respectively. It is worth noting that there are big discrepancies in Spits where no corrections had to be made, e.g. Spit 6 SE18/NE0 (1 piece) and SE20/NE0 (19 pieces).

Density of Pieces of Flaked Stone

In no Spit would I call the artifacts plentiful:

Spit 4.	1 artifact per	85 cu. ins.
Spit 5.	1 artifact per	251 cu. ins.
Spit 6.	1 artifact per	426 cu. ins.
Spit 7.	1 artifact per	1,728 cu. ins.

The Spits are six inches deep. This means that to recover one artifact we could expect to dig areas approximately as follows:

Spit 4. 4 × 4 in.	Spit 5. 6 × 6 in.
Spit 6. 8 × 8 in.	Spit 7. 1 ft 5 in. × 1 ft 5 in.

This general paucity of pieces of flaked stone, coupled with hardness of the deposit, made the area hard to exploit. I felt that it was worthwhile to systematically crush the deposit before sieving, laborious though this was. Any bias towards picking out the larger pieces of flaked stone was thus reduced.

Correlation between GGW-1 and Other Excavations

Since all the deposit excavated at GGW-1 is part of the Keilor Terrace as determined by J. M. Bowler, its contents should be comparable with material recovered from similar levels elsewhere in the terrace. When levels are correlated, there are certain discrepancies in the nature of the collected artifacts from GGW-1 and Mulvaney's excavations. These are discussed elsewhere in this report. Of course stratigraphical correlations between disconnected areas at Green Gully are primarily problems of sedimentology. I here wish to draw attention to three observations relating to the humanly introduced material in GGW-1.

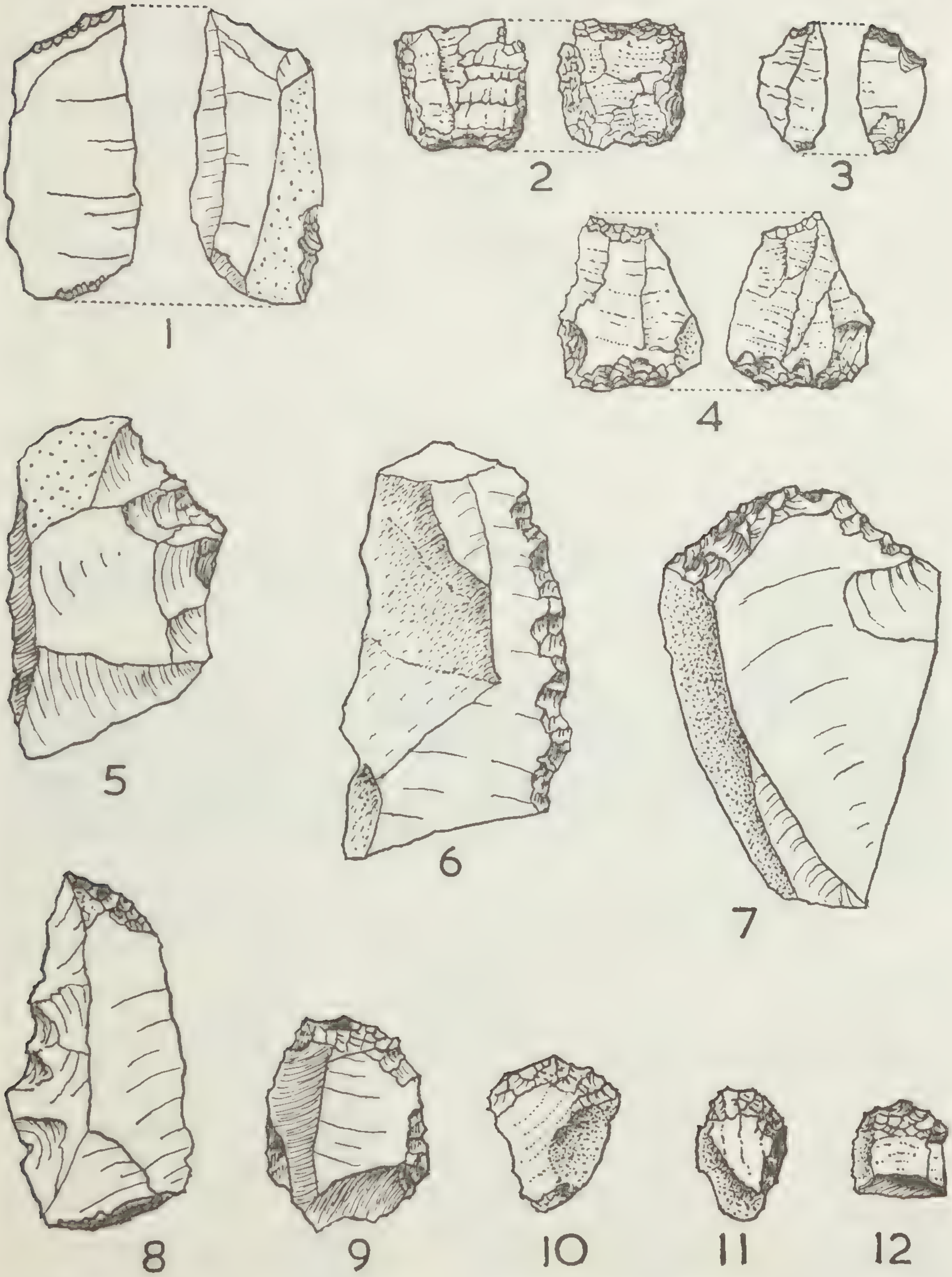


Fig. 1—1 Fabricator (Spit 8), 2 Fabricator (Spit 4), 3 Fabricator (Spit 6), 4 Fabricator (Spit 6), 5 Large nosed scraper (Spit 4), 6 Large scraper (Spit 4), 7 Large scraper (Spit 6), 8 Large scraper (Spit 3), 9 Large scraper (Spit 4), 10 Thumb-nail scraper (Spit 6), 11 Thumb-nail scraper (Spit 3), 12 Thumb-nail scraper (Spit 6). All natural size.

Secondary Work

The secondary work on primary flakes was produced by flaking alone. No grinding is present. Secondary flaking is present in the Spits as shown in Table 6.

TABLE 6

Spits	Actual No. pieces with secondary flaking	Corrected No. pieces with secondary flaking	Flakes with secondary flaking within a Spit
1.	0	—	—
2.	1	>1	1·6%
3.	20	>44	5·8%
4.	28	38	5·3%
5.	15	15	6·2%
6.	18	18	12·3%
7.	1	1	2·8%
8.	2	2	16·7%
	85	>119	

% of total secondarily flaked to total flaked = 6·2%

Comments on Table 6:

1. The percentage of Spit 8 may be unreliable because of the small number of flakes recovered.
2. Spits 3 and 4 yielded the greatest number of pieces with secondary flaking.
3. If Spit 8 is ignored, Spit 6 has the highest proportion of flakes with secondary flaking. However its actual yield is low.
4. The low percentage of Spit 2 is presumably reliable and shows an interesting scarcity of secondary flaking.
5. The proportion of secondary flaking on the site as a whole is ordinary for a stone industry.
6. None of the flakes counted as having secondary flaking could reasonably be classed as flakes used as cores. In fact no cores at all were found.

TABLE 7

Raw Material of Secondary Flaking

Spits	No. Quartz	No. Quartzite etc.	Quartz within Spit	Quartzite etc. within Spit
2.	0	1	0%	100%
3.	8	12	40%	60%
4.	4	24	14%	86%
5.	5	10	33%	67%
6.	14	4	78%	22%
7.	0	1	0%	100%
	31	52		

Total Quartz with secondary flaking as % of total secondarily flaked = 37%
Total Quartzite etc. with secondary flaking as % of total secondarily flaked = 63%

Comments on Table 7:

1. The overall percentage of quartz used for secondary flaking correlates well with its percentage occurrence overall (Table 5).

2. In Spit 3 quartz is relatively more important for secondary flaking than its occurrence overall suggests. In Spit 4 it is less important.
3. The big increase in its use for secondary flaking in Spit 6 correlates with its increased use overall.
4. Its apparent lack of use in Spit 7 can be discounted because only one flake with secondary working was found.

I have divided the flakes with secondary flaking as follows:

TABLE 8

Spits	Large scraper	Thumb-nail scraper	Fabricator	Misc. secondarily flaked
1.	0	0	0	0
2.	0	0	0	1
3.	2	5	3	10
4.	5	2	6	15
5.	2	2	3	8
6.	3	9	3	3
7.	0	0	0	1
8.	0	0	1	1
	12	18	16	39

These types are fairly evenly distributed through the deposit, both horizontally and vertically. To show this, columns NE0 and NE2 have been combined along the whole area excavated. In this way the schematic section of Table 9 has been produced.

An examination of this distribution suggests that there are no differences either laterally or vertically. Actual numbers are of course low. To test whether there are sufficient types to make a statement about homogeneity two chi^2 tests were made using Spits 3-6 inclusive. The first is a test for a significant difference between the five right hand and the four left hand columns of Table 9. The second is a test for Spits 3 and 4 against Spits 5 and 6. Yate's correction was made for both. The results are as follows:

	4 lft. Cols.	5 rt. Cols.
Large Scraper	5	7
Micro Scraper	9	9
Fabricator	4	11

Chi^2 = 1·02
d.f. = 2
probability is greater than 0·3

	Large Scraper	Micro Scraper	Fabricator
Spits 3 and 4	7	7	9
Spits 5 and 6	5	11	6

Chi^2 = 0·83
d.f. = 2
probability is greater than 0·5

Thus, in terms of the categories listed, there is good reason for thinking of the site as homogeneous. The observed differences in Table 9 could well be due to chance.

TABLE 9

'' = large scraper + = micro scraper ≠ = fabricator

Spits									
3				+			'' ≠	+ ≠ +	'' + +
4	'' '' ≠	≠	+ ≠		≠	'' '' ''	≠	≠	+
5	''						'' ≠ ≠ ≠	+	+
6	'' + ≠ +	+ + + +	''	+	+ +	''		≠ ≠	
7									
8	≠								

Discussion of Types

Large scrapers (Fig. 1, Nos. 5-9). These vary in size and form. Secondary flaking can form a convex edge, e.g. Nos. 6 and 7. No. 5 is the only scraper where a nose seems to have been deliberately created. All 12 are made of 'quartzite'.

Micro scrapers (Fig. 1, Nos. 10-12). 16 of the 18 are of quartz. The intention of the artisan was to make a convex scraper edge shaped like a thumbnail. Thumbnail scrapers of the Bondaian industries of coastal N.S.W. regularly have this sort of edge placed opposite the striking platform of a small flake. The GGW-1 specimens do not show this relationship of edge to striking platform. In fact the tiny pieces of quartz on which they are made rarely show striking platforms. It seems then that these micro scrapers were most frequently made on pieces broken off quartz flakes. That the micro scrapers are not merely the small-sized end of the range of large scrapers is shown in Table 10, where both types have been combined.

TABLE 10

Max. dimension of scrapers in cm	Frequency
7·0-7·5	0
6·5-7·0	2
6·0-6·5	0
5·5-6·0	2
5·0-5·5	1
4·5-5·0	2
4·0-4·5	2
3·5-4·0	2
3·0-3·5	1
2·5-3·0	3
2·0-2·5	10
1·5-2·0	5
1·0-1·5	0
	30

(a) the lengths of the two worked edges.
(b) distance between the two opposed worked edges and the average lengths of the two worked edges.
(c) distance between the two opposed worked edges and thickness.
(d) average length of the two opposed worked edges and thickness.

The results were:

(a) $r = +0{\cdot}64$. Significant at the 1% level
(b) $r = +0{\cdot}38$. Not significant at the 5% level
(c) $r = -0{\cdot}39$. Not significant at the 5% level
(d) $r = +0{\cdot}39$. Not significant at the 5% level.

Thus in terms of these tests the only confident conclusion we can come to about correlations is that as one worked edge increases in length so does the other. I am surprised at the evidence for weakness in the other correlations. In particular it appears unlikely that as fabricators get longer they also get thicker. I should stress that these results apply to the fabricators from Lapstone Creek and are not necessarily applicable to those from other sites.

Some other observations

	Unbroken	*Broken*
GGW-1	6 (46%)	7 (54%)
CAPERTEE 3	23 (74%)	8 (26%)
LAPSTONE CREEK	80 (83%)	17 (18%)

	Quartz	*Other rock*
GGW-1	7 (54%)	6 (46%)
CAPERTEE 3	15 (48%)	16 (52%)
LAPSTONE CREEK	43 (44%)	54 (56%)

	1 Pr. Opposed Edges	*2 Prs. Opposed Edges*
GGW-1	12 (92%)	1 (8%)
CAPERTEE 3	28 (90%)	3 (10%)
LAPSTONE CREEK	59 (65%)	32 (35%)

	Convex Edge	*St.Edge*	*Concave Edge*
GGW-1	6 (38%)	4 (25%)	6 (38%)
CAPERTEE 3	15 (37%)	12 (29%)	14 (34%)
LAPSTONE CREEK	77 (46%)	58 (35%)	32 (19%)

This last series of observations, though somewhat impressionistic in the allocation of approximately straight edges, should have shown a drastic incongruity in one of the three sites, if it existed. There are further observations and comparisons that could be made. However, on the basis of those above I see no evidence to support a theory that the fabricators from GGW-1 are a different type of object from those in E. New South Wales.

History of Recognition in Australia

The earliest reference to a fabricator seems to be Thorpe (1931, p. 286, Fig. 10). He calls this a 'button flake'. The type is not discussed but the detail in his photograph is adequate to interpret it as a fabricator with two pairs of opposed edges. Towle (1935, 120) gives a fairly full description, '. . . usually not more than one inch across, and somewhat rectangular or square in form . . . chipped to a working edge from both sides'. He refers to their name of *button flake* but also

Intuitive sorting of the specimens used in Table 10 resulted in my setting 3 cm as the boundary between the two types of scrapers. The micro scrapers show a strong mode. The peaked form of the distribution indicates that there was a tight restriction on their acceptable size. By contrast the large scrapers show no defined mode. This, coupled with their variability in form, suggest that either no good type is present in this industry, or, as seems more likely, the sample from GGW-1 is too small for a pattern or patterns of working to be discerned. I have examined Mulvaney's large scrapers and consider that mine represent the same sorts of implements as his.

Fabricators

(Fig. 1, Nos. 1-4). Otherwise known as *outils écaillés*. Essentially, fabricators show scaled flaking on opposed edges, the same edges being battered to varying degrees. Flaking is usually bifacial and normally only one pair of opposed edges is worked in this fashion. However, occasionally four edges are worked and these two opposed pairs give a final quadrangular form to the object, e.g. No. 2.

Although I had originally taken the identification of fabricators at GGW-1 for granted, I felt after discussion with Mulvaney and others that some comparative work would be an advantage. My original impression remains unaltered that the Green Gully fabricators look like those from coastal New South Wales in range of size and form. I can suggest no function for these objects derived from the other material excavated at GGW-1.

The specimens used from sites other than GGW-1 were identified by myself from the respective collections. My inclusion of a piece of flaked stone into the class rested on the identification of opposed working edges showing scaling and crushing. In examining the collections from Capertee and Lapstone Creek in the Australian Museum, Sydney, it was evident to me that McCarthy and I are very close in our basic diagnosis. I cannot however pursue the discrete nature of his subdivisions.

Some measurements

Distance between two opposed worked edges

GGW-1	15 opposed edges	Mean = 2·5 cm, s.d. 0·7 cm
GYMEA	81 opposed edges	Mean = 2·0 cm, s.d. 0·5 cm
CAPERTEE Site 3	32 opposed edges	Mean = 2·5 cm, s.d. 0·7 cm
LAPSTONE CREEK	118 opposed edges	Mean = 2·3 cm, s.d. 0·6 cm

Length along each worked edge

GGW-1	17 edges	Mean = 1·6 cm, s.d. 0·4 cm
CAPERTEE Site 3	49 edges	Mean = 1·4 cm, s.d. 0·6 cm
LAPSTONE CREEK	224 edges	Mean = 1·3 cm, s.d. 0·7 cm

Thickness (estimated by the smallest opening of calipers through which the fabricator can be fitted)

GGW-1	9 specimens	Mean = 0·9 cm, s.d. 0·2 cm
CAPERTEE Site 3	25 specimens	Mean = 1·0 cm, s.d. 0·4 cm
LAPSTONE CREEK	85 specimens	Mean = 0·8 cm, s.d. 0·3 cm

Apparent discrepancies in the frequencies for individual sites is due to breakage, which affects the suitability of a specimen for some measurements but not for others.

I did some superficial studies of correlation between measured attributes. For this I took a random sample of 15 fabricators from Lapstone Creek which were unbroken and had one pair of opposed edges. I tested for correlation between:

refers to them as scrapers. He suggests their suitability as gouges or gravers. F. D. McCarthy, in a series of articles on stone implements, describes his notion of a fabricator in detail. He first uses the term itself (1941, p. 263) in a general sense, including it within the class *hammerstones*. However, he says, 'Another type of fabricator is a flake which bears a slightly concave and battered edge, due to its use'. Two years later McCarthy (1943, p. 130) makes a comparison between what he calls 'flake fabricators' (*outils écaillés*), hitherto termed 'button flakes', and specimens from South Africa. He suggests that since in N.S.W. they are associated on the coastal dune sites with eloueras and bondi points, flake fabricators may have been used for putting the backing on these implements. He goes on to give a detailed description of their characteristics and range of variation. More information about fabricators is given in McCarthy (1943, pp. 201 and 207), McCarthy and Davidson (1943, p. 221), McCarthy, Brammel and Noone (1946, p. 34 and Figs 101-102).

In the last report they are referred to as 'fabricators and trimming stones'. The allusion to their function as backing implements is analysed further by McCarthy (1948) in his report on the excavations at Lapstone Creek. An examination of his tables on pp. 11-12 shows that there were merely 11 flake fabricators of all types in the Bondaian, whereas 105 occurred in the Eloueran. McCarthy discusses the importance of this discrepancy (1948, p. 21) as it relates to possible function. He points out that it is unreasonable now to interpret flake fabricators as trimmers of Bondi points and suggests that they might have been used for retouching the working edges of eloueras. Though he alludes to this discrepancy in his discussion of function mentioned above, he does not refer to fabricators when discussing the general characteristics of the Eloueran industry (1948, p. 18) except to mention 'chisels' in his microlithic assemblage. Nor does he (1948, p. 22) make enough of the preponderance of fabricators in the Eloueran when generally comparing his Bondaian and Eloueran industries. In drawing attention to this I am to a certain extent being 'wise after the event'. Hume (1965) showed that at a rock-shelter near Sassafras the frequency of fabricators rose near the top of the deposit as the Bondi Points declined. The parallel between the two sites escaped Hume.

So far we have been dealing with assemblages where fabricators occur with artifacts that we associate with a relatively late stage of Australian prehistory. Site 1 at Capertee (McCarthy 1964) confirms this attribution. The fabricators are restricted to the Bondaian and do not occur in the underlying Capertian. However, at Site 3 the situation is not so simple. In his discussion of Layers 6-11 from this site, McCarthy (1964, p. 225) describes fabricators from his Capertian industry, i.e. from levels below those containing Bondaian elements. Radiocarbon dates V-18 and V-34 show that these are between 3·5 and 7·5 thousand years old. Their pre-Bondaian associations are interesting, particularly in the light of Green Gully. McCarthy himself sees fabricators as characteristic of the Capertian (1964, p. 238).

In summary, it appears that in E. New South Wales a type of object with distinctive formal characteristics has been recognized for the past 30-40 years. In the literature there are offered various names and interpretations, but the existence of an actual type does not seem to have been disputed. That their recognition was not peculiar to N.S.W. is evidenced by Campbell and Noone (1943a, p. 297), who describe and illustrate 'punches, chisels and battered pieces', drawing attention to the parallel with the *pièces esquillées* of European Upper Palaeolithic sites. See also Campbell and Noone (1943b, p. 382).

Recognition Outside Australia. I have not surveyed the archaeological literature of the world for a bibliography of the fabricator. Two references are however worth mentioning. McCarthy suggested a functional linkage between fabricators and

other aspects of associated technology. Semenov (1964, pp. 148-149) proposes a relationship of a different kind for Upper Palaeolithic sites in E. Europe. He discusses what sort of tool might have been used to make a continuous circumferential notch in a mammoth tusk prior to snapping. 'It is probable that flakes and blades were used as chisels and gouges. Such specialized tools (*pièces écaillés*) have been found on upper palaeolithic sites, consisting of flakes and even blades with wear facets on both faces. The facets as a rule have a wavy surface with sharp short flaking line and commonly a steep fracture. The character of the facets indicates that they arose not from pressure retouch but by direct blows into the flake in a vertical position on a hard base, and the facets are best regarded as signs of use, not as trimming. There are grounds for considering such flakes and blades as chisels or gouges for working bone and probably wood.' An illustration of reconstructed technique (1964, Fig. 74, 7) shows what is in form clearly a fabricator. Some work I did myself on hard wood shows such an object is readily produced by vertical blows.

The other relevant reference is that of Van Riet Lowe (1946). As well as referring vaguely to possible functions, he also makes comments on the cultural significance of '*outils écaillés*'. Van Riet Lowe too makes the point that the objects were made by a 'bi-polar technique' (1946, p. 241). The piece to be flaked was held vertically on an anvil and struck so that flakes were simultaneously removed from both ends and bifacially. He calls them 'chisels' and, where they have 'secondary trimming', 'scrapers'. Though mentioning their function, he stresses the bi-polar technique of manufacture as the diagnostic trait. They are said to be distributed in the later Stone Age of S. Africa and in the lowest levels of Choukoutien. Breuil told him that they were found in the Aurignacian and Mesolithic of France. 'The bi-polar technique is thus seen to be of very widespread occurrence. It is a manner of stone-fracture and stone-shaping common to many cultures and climes and not exclusively associated with any particular stone culture or time' (Van Riet Lowe 1946, p. 242).

The facts on geographical and temporal distribution seem unquestionable. However, I dispute one implication. I infer from Van Riet Lowe's discussion that he considers fabricators of no significance in matters of cultural tradition and diffusion. Certainly the frequency of their occurrence reduces their diagnostic value. Yet one must remember that they are *not* found in large numbers of industries. Furthermore, the circumstances of their presence and absence do not seem to be entirely random and sporadic, either geographically or temporally. If we couple this with the theoretical unlikelihood of any artisan's choice in stone flaking procedure being free of cultural control, it seems that Van Riet Lowe has said nothing that could not be said of a multitude of stone flaking procedures and artifacts, e.g., pressure flaking, side scrapers. Possibly I have over-strained Van Riet Lowe's account to make a point, but nevertheless the possible implication needs to be dealt with.

In the Australian context, therefore, I conclude by suggesting that the cultural significance of fabricators should not be discounted merely because their form is specific and their method of production readily understood. If we were to use these criteria for rejection, many other modes of flaking and types of implements would have to be called into question. This would be perhaps not a bad thing. At this stage of our knowledge what I want to deflect is special pleading in the case of fabricators.

Miscellaneous Secondarily Flaked. These consist of pieces in which I can see no significance or pattern in the secondary flaking. This is either because it is so limited or because the pieces are too broken up. The majority of the broken pieces seem to be fragments of large scrapers.

Character of the Industry

From the excavated deposit, and in decreasing order of numerical importance, the industry from GGW-1 is characterized by small micro scrapers just over 2 cm in length, by fabricators, and by large scrapers of assorted shapes and sizes. To have extended the area of excavation would have rounded off our knowledge of the industry, but to conclude from Table 9, it would have been unlikely to have added much to its main elements. By amalgamating the four left-hand columns we could have made an acceptable prediction of the contents of the five right-hand columns. We can be fairly confident that to excavate the same amount of deposit again in an immediately adjacent area would not produce any new artifacts of numerical significance.

Conclusions

If this industry is older than 8,000 years then it is not, in its entirety, like any industry of comparable age that I have seen. The large scrapers on their own are an exception to this but they are not found on their own in any Spit at GGW-1. Their associates, micro scrapers and fabricators, out-number them in every Spit. Micro (thumb-nail) scrapers and fabricators have been found in E. New South Wales in the later industries. If I had been shown the GGW-1 industry out of context I should have judged it to have been relatively recent.

The intention of these comments is not to throw doubt on the antiquity of the deposits of GGW-1. Our knowledge is too limited to start arguing contentiously from culture to chronology in Victoria. Nor do I want to be understood as claiming that at GGW-1 we have an early manifestation of an industry that fathered the later industries of coastal N.S.W., such as the Bondaian. There are many traits present in the latter complex not present at GGW-1. In fact I cannot reasonably integrate GGW-1 with any other archaeological site in Australia. However, I feel the character of the industry is established firmly enough to predict that other sites will be found with the same industry of the same age. It is a useful antidote to an impression I had been forming that 'anything early is big'.

References

Campbell, T. D., and Noone, H. V. V., 1943a. South Australian Microlithic Stone Implements. *Rec. S. Aust. Mus.* 7: 281-307.

————, ————, 1943b. Some Aboriginal Camp Sites in the Woakwine Range Region of the South East of Australia. *Rec. S. Aust. Mus.* 7: 371-396.

Hume, S. H. R., 1965. The Analysis of a Stone Assemblage to Determine Change. Unpublished B.A. Hons. Thesis, Department of Anthropology, University of Sydney.

McCarthy, F. D., 1941. Chipped Stone Implements of the Australian Aborigines. *Aust. Mus. Mag.* 7: 257-263.

————, 1943a. An Analysis of the Knapped Implements from Eight Elouera Industry Stations on the South Coast of N.S. Wales. *Rec. Aust. Mus.* 21: 127-153.

————, 1943b. The Coroid and Knapped Stone Implements of the Bathurst District. *Rec. Aust. Mus.* 21: 199-209.

————, 1948. The Lapstone Creek Excavation. *Rec. Aust. Mus.* 22: 1-34.

————, 1964. The Archaeology of the Capertee Valley, N.S. Wales. *Rec. Aust. Mus.* 26: 197-246.

————, and Davidson, F. A., 1943. The Elouera Industry at Singleton, Hunter River, N.S. Wales. *Rec. Aust. Mus.* 21: 210-230.

————, Bramell, E., and Noone, H. V. V., 1946. The Stone Implements of Australia. *Mem. Aust. Mus.* 9.

Megaw, J. V. S., 1966. The Excavation of an Aboriginal Rock-Shelter on Gymea Bay, Port Hacking, N.S.W. *Archaeol. and Phys. Anthrop. Oceania.* I: 23-50.

Semenov, S. A., 1964. *Prehistoric Technology*, London.

Thorpe, W. W., 1931. Aboriginal Flaked Implements. *Aust. Mus. Mag.* 4: 286-288.

Towle, C. C., 1935. Stone Scrapers: An Inquiry Concerning a Certain Conventionalized Type Found along the Coast of New South Wales. *J. Proc. Roy. Soc. N.S.W.*, 68: 117-143.

Van Riet Lowe, C., 1946. The Coastal Smithfield and Bipolar Technique. *S. Afr. J. Sci.* 42: 240-246.

THE GREEN GULLY REMAINS

By N. W. G. Macintosh
University of Sydney

Abstract

A summary is presented of Professor Macintosh's published accounts of his preliminary examination of the Green Gully remains. The physical condition of the bones, their excavation and laboratory treatment are described, together with some tentative assessment of their status and anomalous features.

Introduction

The archaeologists attempted a very thorough job of field recording of each stage of the excavation, by use of notes, diagrams, scale measurements of levels and surveys, still colour plus black and white photography, and colour motion picture film. Inclement weather, particularly rain, and a mishap to one camera resulted in close-up photographic studies of the bones *in situ* being somewhat short of perfection. Nevertheless, sufficient photographic record is available to indicate how the bones appeared to Casey and his team.

Occurrence and Collection

In these photographs there is no bone which does not show fracture, indeed multiple fractures, and secondly the anatomical relations of these bones one to another are much disturbed. For example, the clavicles are parallel instead of transversely in line; the right femur is dislocated out of the acetabulum and rotated through 180°; by diagrammatic projection of the residua of the shafts it seems obvious that the lower end of the right femur and the upper end of the right tibia must have been at least 16 in. apart; the dorsum of the right hand bones and the dorsum of the right forearm bones appear to be contiguous.

Such distortion of relationship simply does not happen following burial of an intact corpse in ground which is free from disturbance such as this appears to have been, i.e., an infilled grave marginally delineated from the surrounding medium of intact soil structure. Therefore it seems necessary to assume that it was not a corpse, but a skeleton which was buried some 12 months after death and after most of the flesh had gone from the bones. In other words, this would seem to have been a 'delayed burial'. Delayed burial is practised by aboriginal Australians today in Arnhem Land, and writers in the 1800s recorded the custom in S. Victoria. The Green Gully bones would appear to indicate that the custom goes back some thousands of years. This is an astonishing example of the force of sanction, and persistence of traditional behaviour.

It can be seen also from the field photographs that the front-end loader sliced off the norma facialis of the skull, the inferior halves of the femora, superior halves of the tibiae and part of the shaft of the left humerus. These broken pieces rolled down the slope. Casey's men sieved the base of the slope and separately boxed all bone fragments and artifacts therefrom in 24 cardboard containers. (All human bone fragments from this collection down the slope have now been fitted to the fractured margins of bones taken from the grave).

The field workers were concerned about the removal and preservation of bones in the grave. 'As the earth was removed from above them they were painted with a

of bicipital groove and anterior aspects of the greater and lesser tuberosities. The problem at the lower end was more complicated; medial epicondylar area, lateral epicondylar area, and trochlea area were not only lying separate from themselves and from the shaft, but were also each found to be separated into an anterior and posterior Bedacryl-clogged mosaic of chips. Each portion was dealt with in accordance with the method described above. In joining the portions together, it was necessary to re-dissolve adhesive, and readjust some of the adjacent edges of chips already positioned, but now, free of the obscuring Bedacryl and matrix, this could be done with less risk of loss of the fragments or of failure to identify the margins of the chips; 37 fragments were successfully reassembled at the lower end, but a small ragged gap remains unrestored in the olecranon fossa and there is a small deficiency at the lateral epicondyle.

The three transverse fractures of the shaft were found to be welded together by very hard carbonate crust 1·0 to 4·0 (average 2·0) mm thick. It was obvious that cracks in the bone had been invaded by carbonate in ground water solution. The carbonate had deposited in the cracks and there aggraded, forcing the cracked fragments apart. This is quite certain, because plugs of this crust were found to extend up and down the marrow cavity for distances of 1·0 to 5·0 cm from the fracture lines. Hence these are ancient fractures and the question presented itself as to whether they were pre- or post-mortem breaks.

The crust was soaked with dilute acetic acid, but even so had to be drilled away with steel dental drills. The plugs in the marrow cavity were particularly recalcitrant. It was then found that the cleaned bone edges provided perfect alignment, and no artificial trimming of bone whatsoever was necessary for perfect fit. As right-angled notching in the lines of fracture occurred in five places, it appeared that these were post-mortem breaks. Plugs of trimmed balsa wood plus adhesive inserted into the marrow cavity completed reassemblage of the shaft, and this right humerus can be regarded as 95 per cent complete and hence is one of the very few bones in the total recovery that is available for measurements and subsequent calculations by formulae to assess the stature of the individual, and other deductions.

Fractures

Three types of fracture were recorded in the total bony remains. First, the ancient post-mortem fractures as described above, which were immediately identifiable by the accumulated grey crust on the fracture margins. Secondly, fissure fractures, particularly where the cortex was thin or where the bone had undergone decay and disintegration in the ground. Here there was no marginal crust accumulation, but the edges were dark brown. I have no reports so far on chemical, grain size or other analyses of the matrix, but the matrix when immersed in water and subsequently strained is seen to be fine grained and glutinous. On drying out it shrinks and cracks into plaques of a characteristic pattern. I would therefore think that expansile-contractile clay is involved and is probably the agent responsible for the multiple minute fractures and the multiple fragmentary bone chips. Thirdly, there were recent fractures (a) caused by the front-end loader, and these were severe, (b) others caused in field excavation, and these would seem to have been minimal, and (c) fractures due to squeezing by the applied protective wrappings as they contracted in drying out. This effect was severe on the ribs, which were mere cortical shells. All these recent fractures were obvious because of their fresh white margins. (A fourth type, pre-mortem, will be referred to later.)

The surfaces of the bones had only a trace of carbonate crust ranging from nil to 0·5 mm, best seen on the inner table of the skull bones, adjacent to which the matrix showed minute beading of carbonate deposition. But here and there, for

strengthening solution of Bedacryl in acetone and covered with several layers of tissue paper pasted on to protect them from the plaster of Paris used for reinforcement' (Bowler *et al.*, 1967). Three blocks—the head, the trunk plus limbs, and the feet—were encased in a three-quarters or four-fifths surround of plaster of Paris; the three blocks were then undercut, and subsequently surrounded by foam rubber, and crated for transport. The theory in this preparation was that removal of plaster of Paris could be effected with ease or at least safety because of the underlying several layers of tissue paper, which in turn could be easily removed because clag is water-soluble; then the Bedacryl could be removed by dissolving with acetone.

Four factors operated against consummation of such intention. The plaster of Paris (surgical bandages) had been moulded to the shapes of the bones; in drying, the plaster bandages underwent shrinkage and tightly compressed the underlying layers of tissue paper to a single papier-mache-like layer also tightly moulded to the bone; the clag of the tissue paper, the Bedacryl and the clayey matrix had combined to form a compound which was not soluble in any of a number of reagents tried. Finally, this compound had, in some places, most firmly bound itself to the sub-periosteal basal lamina of the bone which scaled off under the least traction, thereafter defying identification. Much time was spent on experiments in the Department of Anatomy before we plunged into the actual operation, and indeed similar experimenting and modifications of technique continued right up to the moment of extraction of the last piece of bone from matrix, 2 January 1967.

Cleaning and Conservation

The problem was overcome by using a one-centimetre traverse oscillating saw, mounted in pistol grip and electrically driven, to fenestrate the plaster of Paris. The frames of these scores of small windows were then in turn cut through, and so pressure or wrenching effects on the underlying bones were avoided. It was ultimately found that 40 per cent xylol in acetone would convert the compound of clag-Bedacryl-matrix to a latex or chewing gum-like consistency, which could then be teased up with forceps and dissected off the bones; some dozens of Howard-Parker detachable blades were used up in this work. Details of this complex task of conservation and reassemblage of the various bones will be presented as a separate paper at some later date. Reference is here made only to the conservation and reconstruction of the right humerus. The field photographs permitted one to see three transverse fractures of the shaft more or less equi-distant, and the head of the humerus and the lower end appeared to be at least partially detached and fragmented.

After the coverings had been removed, it was found that a gap measuring $7{\cdot}0 \times 2{\cdot}3$ cm existed at the upper end of the shaft involving the region of the bicipital groove. Bone from this gap was adherent as a mosaic of chips to the inner aspect of the applied Bedacryl-clag-matrix. This area of wrappings was trimmed with scissors, laid on a broad spatula, supported around its margins so that the chips could not float away or otherwise disperse from one another, and the whole immersed in a lidded tray with a shallow ($1{\cdot}0$ cm) depth of acetone and xylol. After 24 hours, each chip was separately removed in turn and joined progressively to its neighbouring chip. Had the chips become dispersed, it would not have been possible to identify all adjacent margins correctly; this gap in the shaft was completely restored by this reassemblage of a total of 13 fragments ranging in size from $0{\cdot}3 \times 0{\cdot}6$ cm to $4{\cdot}3 \times 1{\cdot}3$ cm. One contact edge, 1 cm long, between shaft and head, was available at the postero-medial margin of the anatomical neck. Without this, repositioning of the head on the shaft would have been no better than an educated estimation. There remains a small deficiency of bone at the upper margins

example on the right proximal phalanx of the great toe, at two places on the left femur, and elsewhere, there were isolated random plaques of hard crust 5 to 7 mm. thick which had to be drilled off. This is instructive because it indicates the burial must have occurred at the very terminal part of that climatic period which was responsible for the carbonate-containing stratum, 6 ft thick, in the top level of which the grave occurred.

Bone Colour

Progress photographs in black and white and also colour were taken at successive stages of removal of the bones from their protective wrappings and the contained matrix. Everything has been kept in separate containers, i.e. sediments, crust scrapings or drillings from individual bones, artifacts, gravel, adventitious rock pieces, and so on. The colour of the matrix was seen to be different in different regions of the skeleton. The upper trunk bones were enveloped in a light brownish to ochre coloured matrix with patches of pinkish-red and ash-dark-soil alternating in random fashion, minute charcoal chips and fine gravel intermingled. The lower trunk and upper femora rested in a more uniformly chocolate brown matrix and the feet in a very dark brown soil with considerable fine gravel. Soil filling the cranial cavity was distinctly and uniformly reddish brown.

The bones themselves show no sign whatsoever of firing; they are neither burnt nor smoke-stained. There is a pale bluish colouration on their surfaces (Tindale uses the term 'bluish bloom' to describe this appearance). This was not absolutely uniform, but its actual extent is now uncertain. It removes very readily by rubbing, scraping or polishing, exposing then a dirty white or light khaki surface. In removing the adherent Bedacryl-matrix-clag by dissection, particularly where it was intractably adfixed, this 'bloom' and also any carbonate film, could not be observed, but that is not to say it was not present. My impression at this post-operational stage is that the lower extremity bones exhibited pronounced and uniform 'bloom', the skull bones some patchy 'bloom', and the trunk and right upper extremity bones a trace.

Bone Identification

A normal skeleton has 236 bones counting individual skull bones, auditory ossicles, sesamoids, separate sacral, coccygeal and sternal segments. But the Green Gully bone fragments numbered 3,900 pieces. The task of identication has therefore been severe. Of these 3,900 pieces, only 730 could be identified and used for reassemblage. Some hundreds of other fragments were recognized partly from their appearance and partly from their relative positions in the matrix blocks, as being chips of ribs, thoracic vertebrae, and so on, but no reconstructive use could be made of them.

The 730 identified and usable fragments were immersed in 25 per cent Bedacryl in xylol, or in Tarzan's Grip *q.s.* in acetone, under vacuum for 24 to 48 hours to harden the bone. This technique was found, after many experiments, to give best results, and the product has sustained plastic and polyester resin replica production without harm.

These bones were then photographed separately and life-size prints were stuck down on a panel *pari passu* with the reassemblage of the fragments themselves by adhesive. From the actual reassemblage of the bones, it can be seen that these 730 pieces constitute approximately only two-fifths of a total skeleton, so it is neither 'almost complete' nor 'in good condition'.

All the remaining fragments were no larger than about a centimetre and have been utilized for specific tests. Two thousand seven hundred and eighty-two fragments, weighing 136 gm, were sent to Athol Rafter, Director of the Institute of

Nuclear Sciences, D.S.I.R., New Zealand, for radiocarbon test. Eighty-six fragments, weighing 4·3 gm, from the feet bones and 16 pieces, weighing 5·0 gm, from thoracic vertebrae were sent to Dr K. P. Oakley, British Museum, for fluorine-nitrogen-uranium test. Sixteen pieces, weighing 7·5 grams, from thoracic vertebrae and estimated to contain approximately 3·0 gm of cancellous bone, were sent to Michael Charney, Colorado, for ABO group test together with separate samples of soil from the skull interior, the upper trunk and the feet.

Turning now to the 730 reassembled pieces constituting two-fifths of a skeleton, the following observations are necessarily tentative, because almost nine months of technical preparation of these bones, involving an average of 16 hours per week, has meant that one is only now in a position to begin an actual thorough study of them as a whole. At this point I pay tribute to my technical staff, Messrs. B. Bailey and S. L. Larnach (bone preparation and identification)), G. Williams (photography), K. Parsons (replicas and chemicals), P. Mills (drawings, panel, etc.), who in varying degrees shared the work with me.

Our first and somewhat alarming observation was that the left humerus is quite obviously on inspection and by measurement, much larger than the right humerus. Only the middle two-thirds of the shaft of the left humerus has survived, and it is broken near its mid-point. The inferior portion was recovered from the base of the slope where the front-end loader was working, while the superior portion came out of the grave matrix. The broken ends fitted together perfectly and the lower portion had obviously been dislodged by the front-end loader.

Actual measurements are confined to shaft diameters and in this the left is uniformly larger than the right humerus. The actual length of the surviving portion of the left shaft is greater than the length of the right between estimated analogous points. Approximately three-quarters of the left humeral head survives, and as far as present study has gone, it appears to have analogous dimensions, curvature and modelling with the right humeral head (which is intact). The glenoid fossae of the right and left scapulae (which are fragmentary) have equal dimensions. The right and left clavicles are approximately equal in dimensions, slender, rather small, and suggest female sex. It seems necessary to conclude that the right humerus and the left humeral shaft derive from two individuals, not from one.

The bones of the lower extremities appear to be disproportionately large and rugged when compared with the right upper extremity bones, with the clavicles, with the remnants of the scapulae, with the rib fragments, and with the skull.

The pelvic bones have not survived, but small fragments of external plate of ilium were recognized, and then, part of a femoral head and a small portion of acetabular fossa were identified. Our present opinion is that the latter two pieces are mutually adaptable in curvature, size and fit. More study is necessary to confirm or deny this very important question. Subsequently Casey has loaned me a small series of Kodachrome frames which I had not seen previously. They show the bones *in situ* in the field, and the colour definition is good. The pelvic bones were among those referred to by the field workers as mere ghosts in the matrix, but they appear in these frames to be more like the bones of the lower extremities in having a pronounced blue 'bloom', whereas the thoracic and right upper extremity bones show none, and the skull some mottled blue.

Pathology

The present stage of study indicates that the remains show no evidence of pathology except for the following:

1. Pre-mortem fractures are present in the right ulna 7·0 cm above its distal end and in the right radius some 5·0 cm above its distal end. These fractures had

been severe, probably comminuted and possibly compound with anterior and lateral displacement of the inferior portions. Union (with or without treatment) had occurred in bad position with overlap, and thus shortening, of 1·0 to 1·5 cm, and each fracture site had healed with marked sigmoid curvature, particularly the ulna fracture. This probably involved some limitation of right wrist function and so might possibly call for further thinking about the more massive left humeral shaft.

2. A foramen is present in the middle of the articular surface of the distal end of the left tibia. The lower end of this left tibia is represented by a fragment only some 4·0 cm in length. Analogous bone from the right side has not survived, so it is unknown whether or not the feature was bilateral. The foramen leads into a canal which traverses as much of the fragment as has survived. I can find no reference to such a foramen in the literature. Photographic magnifications of the aperture suggest bone reaction at the margins, but might equally represent digestion and secretion or excretion effects of some worm-like creature. It has been examined by Davies of London, Sunderland and Ray of Melbourne, and pathologists from Melbourne, Brisbane and Sydney. We cannot interpret it.

3. Surviving teeth are excessively worn occlusally, even for an aboriginal, so either the diet was very harsh or she used her teeth excessively in chewing fibre to make nets, string, etc. In an aboriginal female this degree of wear would suggest an age of 40-45. But the sutures of her skull suggest an age of only 30-35. These teeth are small, falling inside recorded size range of aboriginal female teeth and outside the size range of male aboriginal teeth (Macintosh and Barker 1965). Three complete teeth and fragments of roots and crowns of perhaps four or even five more have been recovered. Of these the right upper lateral incisor and canine and two root apices of first premolar are *in situ* in portion of the right maxilla. A plastic cast of the matrix mould which had partially surrounded the missing right upper incisor enables its dimensions to be calculated.

Interpretation

This is not the place, nor has sufficient study been completed, to deal with all the anatomical detail, measurements, formulae and calculations. Instead, I say simply for the moment that the left humeral shaft and the bones of the two lower extremities (and maybe the pelvis) in appearance and measurements suggest male, and all the rest is female. The skull is female; there is no question about that.

Compared with aboriginal measurements and statistics from N.S.W. skeletons and from data in the literature, the Green Gully presumptive male bones would seem to fall high within male ranges. The presumptive female Green Gully bones would seem to fall low within male ranges and high within female ranges. We need now to compare the Green Gully skull with other Australian prehistoric crania. Of these there are only four which are significant, viz., the Talgai cranium from Queensland, the Cohuna cranium from the Murray River region, the Mossgiel skull from far western N.S.W., and the Keilor cranium from only two miles away. They are each male, which makes the comparison more difficult.

The Green Gully skull, although gracile, is quite large for a female but significantly smaller than Keilor, Cohuna and Mossgiel. In shape it is not at all like Talgai, Mossgiel or Cohuna, but it is very like the Keilor cranium. When photographically enlarged to the same size as the Keilor cranium, and then superimposed on Keilor photographs, the similarity is striking. Some discrepancy exists at the occipital region which may be a reflection of sex difference, or may turn out to be inaccuracy in our reconstruction. This was the last region assembled, and it was hurried. We propose to dissolve the adhesive and re-study the alignment of the edges of the fragments. Assuming for the moment that later study will confirm this

identification of a male and female assemblage of bones, it is necessary to note that only the right humerus, the bones of the right second manual digit and the proximal phalanx of the right great toe are length-wise intact and these constitute a meagre basis for stature calculations by formulae. Extrapolations from circumferences and horizontal diameters give some assistance. From these scanty data, the tentative suggestion is made that the male may have been about 5 ft 7 in., which is a little above aboriginal average, and the female may have been about 5 ft 5½ in., which is tallish for an aboriginal woman.

Once again, assuming that more meticulous study confirms these tentative decisions, how is this astonishing and unique find to be explained? First, no bone in the assemblage is duplicated. Secondly, the assessed male bones form a block consisting of lower extremities, probably pelvis, and left upper extremity. The assessed female bones form a unit of head and neck, thorax, right upper extremity, and both shoulder girdles. There is absolutely no evidence of departure from these two units, no evidence of a random melange of non-matching individual bones. Thirdly, the vertebral column is represented by the first and second and perhaps a piece of third cervical vertebrae; by a massive collection of thoracic vertebral fragments, identified almost solely on their position in the matrix; by a maximum of three fragments of lumbar vertebrae derived from (?) the third and fifth, and perhaps a fragment of sacral promontory. In other words there is a gap in vertebral representation between upper cervical and upper thoracic, and also between lower thoracic and mid or lower lumbar. Those are the observed facts in an admittedly most fragmented and incomplete assemblage of bones. Do these observed facts nevertheless lend themselves to interpretation?

Only one explanation will satisfy the circumstances: A male and a female body were adjacently exposed while awaiting their 'delayed burials'. When nature had reduced the bodies to bones, the aboriginal mourners gathered up and buried in one grave some two-thirds of the female and about one-third of the male. The obvious question arises, was this by accident or design? We have no means of deciding with certainty, but I favour the view that it was accidental. The Sydney police have brought to me from time to time remains of individuals who had died of exposure on the western plains, or nearer to Sydney in the Hawkesbury scrub. Remnants of skin and tendons and ligaments, although fenestrated by carrion beetle, had become semi-tanned or semi-mummified by the elements and served to hold together a majority of the bones of the limb concerned. Two such tattered arms mounted in perspex by my Department can be seen in the Scientific Branch of the Sydney C.I.D. The remainder of the individual was not found, apparently having been dispersed by crows, hawks, or eagles. The proximal bones ended in oblique fracture lines, not unlike that at the proximal end of the Green Gully left humeral shaft. I visualize the remains of the male and female corpses awaiting 'delayed burial' being similarly disturbed by predators. When the mourners came to inter one of the individuals, they were faced with the task of selecting and arranging the remains of one individual from the partly separated and scattered remains of two individuals, and not being anatomists they got the limbs mixed.

It is easy to visualize the head detaching itself from the trunk at the cervical region; indeed one would expect this, also to visualize the body separating at the lumbar region into an upper portion and a lower portion. The bones of these separated portions might well be maintained in loose relationship to one another by air-mummified tendons and ligaments. These visualizations may sound contrived, but their occurrence is relatively commonplace in forensic experience. In any case, what other explanation will fit all the observations? It is of course possible to argue deliberate intent, stemming from any emotion ranging from love to punitive revenge.

In conclusion, it can only be repeated that much more anatomical study is

necessary, before arriving at definitive opinion. Study so far has been almost totally limited to observations incidental to the enormous task of extracting the bones from their matrix and field coverings and to the conservation treatment, identification and assembly of the 730 usable fragments which constitute a grievously incomplete representation of only two-fifths of a total skeleton which in turn presents considerable evidence that it derives from the upper part of a female and the lower part of a male, that is, two different individuals.

Meanwhile, I feel it is safe to say that the assumed male and female bones, while large, are within the ranges recorded for modern aboriginals. The skull is Keilor-like, not Talgai-Cohuna-Mossgiel-like. The Keilor cranium undoubtedly is somewhat older, but whatever its age its morphological configuration has in general terms persisted until 6,460 years ago in S. Victoria, as exhibited by the Green Gully remains.

References

Bowler, J. M., Mulvaney, D. J., Casey, D. A., and Darragh, T. A. 1967. *Nature* 213: 152.

Macintosh, N. W. G., and Barker, B. C. W., 1965. The Osteology of Aboriginal Man in Tasmania. *Oceania Monograph*, 12.

Note

This account of the Green Gully remains has been edited with the author's consent from his Presidential Address, Section F, ANZAAS Congress, Melbourne 1967. (*Aust. J. Sci.* 30: 86-98). In a later address to the Australian College of Dental Surgeons, Canberra, 1967, Professor Macintosh provided the additional information that tests performed by Michael Charney, University of Colorado, U.S.A., indicated 'that a small sample of bone and of matrix each gave test-results for blood Type O'. (*Ann. Aust. Coll. Dent. Surg.* 1: 108-126).

—D.J.M.

Brown Prior Anderson Pty Ltd 5 Evans Street Burwood 3125